OVERVIEW ECONOMIC ASSESSMENT OF REMEDIAL ACTION PLANS FOR THE GREAT LAKES' AREAS OF CONCERN

APPENDICES

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APRIL 1990

DISCLAIMER

APPENDIX A

COST ESTIMATES FOR
EACH OF THE RAP SITES

TECHNICAL DEFINITIONS

The following three financial terms are used in the cost tables for each of the 17 RAP sites:

- *total capital:* This identifies the total capital cost, in 1989 dollars, of carrying out an identified remedial action.

- annual O&M: This is the annual operating and maintenance cost, again in 1989 dollars, for the remedial actions.

- UAC (Uniform Annual Cost): The UAC of a remediation action represents an annual cost which is equal to the sum of the annual o&m costs and the annualized capital costs of the remedial action. Thus, the UAC represents a series of equal annual payments for the remediation which is equivalent in value to the capital costs and the o&m costs of the remediation action.

NOTES TO BAY OF QUINTE COSTING TABLES

1. BAT costs were not estimated for Corby Distilleries.

2. Some actions which were suggested by the RAP team were also not costed due to lack of detail on plant operations. This includes phosphorus removal from industrial point sources.

3. All costs were estimated by the RAP team except urban runoff where Apogee estimated the costs.

4. Sport fishing costs were not estimated as the RAP coordinator suggested that a healthy sport fishery currently exists in the Bay.

RAP SITE: BAT OF QUINTE 19/3/90

SOURCE OF INFORMATION: ALL INFORMATION FROM RAP TEAM EXCEPT COSTING FOR URBAN RUNOFF

AESTHETICS

SOURCE

STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)		ACTION
Trenton	1,715,300	25,225	208,388	(1)	Tertiary treatment with additional phosphorus removal
CFB Trenton	1,059,450	14,126	127,256	(1)	Tertiary treatment with additional phosphorus removal
Belleville	3,733,300	55,495	454,143	(1)	Tertiary treatment with additional phosphorus removal
Deseronto	353,150	5,045	42,755	(1)	Tertiary treatment with additional phosphorus removal
Napanee	1,210,800	18,162	147,453	(1)	Tertiary treatment with additional phosphorus removal
Picton	817,290	10,090	97,362	(1)	Tertiary treatment with additional phosphorus removal
Prince Edward Heights	3,027,000	0	323,228	(1)	Tertiary treatment with additional phosphorus removal

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Campbellford		8,000	8,000	Secondary	6.3	4.8
Peterborough		60,000	60,000	Secondary	50.8	52.4
TOTAL COSTS FOR STPs	11,916,290	196,143	1,468,585			

SOURCE

Water Treatment Plants

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)		ACTION
Trenton	171,530	0	18,316	(2)	Remove phosphorus from discharge of WTP
Belleville	262,340	0	28,013	(2)	Remove phosphorus from discharge of WTP
Deseronto	20,180	0	2,155	(2)	Remove phosphorus from discharge of WTP
Napanee	110,990	0	11,852	(2)	Remove phosphorus from discharge of WTP
Picton	136,215	0	14,545	(2)	Remove phosphorus from discharge of WTP
TOTAL COSTS FOR WATER TREATMENT PLANTS	701,255	0	74,881		

RAP SITE: BAY OF QUINTE (cont'd)

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	13,822,592	1,476,000	2,952,000	98400

MITIGATIVE ACTION

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)
3. Flush Lake Ontario water into the Bay of Quinte			
3A. 20 m^3/sec	12,814,300	605,400	1,973,733
3B. 35 m^3/sec	13,520,600	1,109,900	2,553,653
4. Reduce feedback of sediment by means of alum treatment.			
Assumes approx. $8 mill. spent every three years	0	2,690,667	2,690,667
RANGE OF COSTS OF MITIGATION	12,814,300 to 0	605,400 to 2,690,667	1,973,733 to 2,690,667
RANGE OF TOTAL COSTS FOR AESTHETICS	39,254,437 to 26,440,137	2,277,543 to 4,362,810	6,469,199 to 7,186,133

Notes:

1. Remedial options which are numbered make up various scenarios for nutrient reduction in the Bay.
2. There are three ways of reducing phosphorus levels in the Bay. Either options 1 & 2, option 3, or option 4.

RAP SITE: BAT 0F QUINTE

SWIMMABLE

SOURCE

STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION		
Trenton	1,715,300	25,225	208,388	(1) Tertiary treatment with additional phosphorus removal		
CFB Trenton	1,059,450	14,126	127,256	(1) Tertiary treatment with additional phosphorus removal		
Belleville	3,733,300	55,495	454,143	(1) Tertiary treatment with additional phosphorus removal		
Deseronto	353,150	5,045	42,755	(1) Tertiary treatment with additional phosphorus removal		
Napanee	1,210,800	18,162	147,453	(1) Tertiary treatment with additional phosphorus removal		
Picton	817,290	10,090	97,362	(1) Tertiary treatment with additional phosphorus removal		
Prince Edward Heights	3,027,000	0	323,228	(1) Tertiary treatment with additional phosphorus removal		
	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Campbellford		8,000	8,000	Secondary	6.3	4.8
Peterborough		60,000	60,000	Secondary	50.8	52.4
TOTAL COSTS FOR STPs	11,916,290	196,143	1,468,585			

SOURCE

Water Treatment Plants

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
Trenton	171,530	0	18,316	(2) Remove phosphorus from discharge of WTP
Belleville	262,340	0	28,013	(2) Remove phosphorus from discharge of WTP
Deseronto	20,180	0	2,155	(2) Remove phosphorus from discharge of WTP
Napanee	110,990	0	11,852	(2) Remove phosphorus from discharge of WTP
Piston	136,215	0	14,545	(2) Remove phosphorus from discharge of WTP
TOTAL COSTS FOR WATER TREATMENT PLANTS	701,255	0	74,881	

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RAP SITE: BAT OF QUINTE

SOURCE **Urban Runoff**	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	13,822,592	1,476,000	2,952,000	98400
MITIGATIVE ACTION	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	
3. Flush Lake Ontario water into the Bay of Quinte				
3A. 20 m^3/sec	12,814,300	605,400	1,973,733	
3B. 35 m^3/sec	13,520,600	1,109,900	2,553,653	
4. Reduce feedback of sediment by means of alum treatment.				
Assumes approx. $8 mill. spent every three years				
	0	2,690,667	2,690,667	
RANGE OF COSTS OF MITIGATION	12,814,300 to 0	605,400 to 2,690,667	1,973,733 to 2,690,667	

Notes:

1. Remedial options which are numbered make up various scenarios for nutrient reduction in the Bay.
2. There are three ways of reducing phosphorus levels in the gay. Either options 1 8 2, option 3, or option 4

SOURCE **Agricultural** **Non-Point Sources**	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)
Farmland		3,333,379	3,333,379
RANGE OF TOTAL COSTS FOR SWIMMABLE	39,254,437 to 26,440,137	5,610,922 to 7,696,189	9,802,578 to 10,519,512

RAP SITE: BAY 0F QUINTE

EDIBLE FISHERY

SOURCE

Water Treatment Plants

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
Trenton	171,530	0	18,316	Eliminate all discharges to the Bay of Quinte
Belleville	262,340	0	28,013	Eliminate all discharges to the Bay of Quinte
Deseronto	20,180	0	2,155	Eliminate all discharges to the Bay of Quinte
Napanee	110,990	0	11,852	Eliminate all discharges to the Bay of Quinte
Picton	136,215	0	14,545	Eliminate all discharges to the Bay of Quinte
TOTAL COSTS FOR WATER TREATMENT PLANTS	701,255	0	74,881	

SOURCE

Industries

Organic Chemicals	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)
Bakelite Thermosets	1,100,000	175,000	337,746
Pulp and Paper			
Domtar	500,000	120,000	193,975
Domtar Packaging	1,800,000	120,000	386,312
Trent Valley Paperboard	1,300,000	100,000	292,336
TOTAL COSTS FOR INDUSTRIES	4,700,000	515,000	1,210,369

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	13,822,592	1,476,000	2,952,000	98400
TOTAL COSTS FOR EDIBLE FISHERY	19,223,847	1,991,000	4,237,250	

NOTES TO COLLINGWOOD HARBOUR COSTING TABLES

1. Other sources of phosphorus to the Collingwood STP are NACAU Starch and Canada Mist. There are occasional sewage treatment plant upsets due to industrial upsets at the above plants.

2. The assumption for feedlot estimates was that there is one head of cattle for every hectare of farmland in the watershed.

3. The RAP coordinator provided an estimate of head of cattle for purposes of costing the agricultural non-point source control. Additional phosphorus removal for the STPs and urban runoff costs were estimated by Apogee.

SOURCE OF INFORMATION: HEAD OF CATTLE ESTIMATE FROM THE RAP COORDINATOR ALL OTHER INFORMATION FROM APOGEE

AESTHETICS

SOURCE
STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Collingwood Harbour	40,809	4,358	8,715	Secondary	16.1	13.59
TOTAL COSTS FOR STPs	40,809	4,358	8,715			

SOURCE
Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	1,784,013	190,500	381,000	12700

SOURCE
Agricultural Non-Point Sources

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	LOADINGS	HECTARES
	468,058	49,980	99,960	0	1700

Feedlots	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	HEAD
RANGE OF TOTAL COSTS FOR FEEDLOTS	366,168 to 636,813	1,734 to 3,468	40,834 to 71,468	1700
RANGE OF TOTAL COSTS FOR AGRICULTURAL NON-POINT SOURCES	834,226 to S1,104,871	51,714 to $53,448	140,794 to $171,428	
RANGE OF TOTAL COSTS FOR AESTHETICS	2,659,048 to 2,929,693	246,572 to 248,306	530,509 to 561,143	

RAP SITE: COLLINGWOOD HARBOUR

SWIMMABLE

SOURCE
STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Collingwood Harbour	40,809	4,358	8,715	Secondary	16.1	13.59
TOTAL COSTS FOR STPs	40,809	4,358	8,715			

SOURCE
Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	1,784,013	190,500	381,000	12700

SOURCE
Agricultural Non-Point Sources

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	LOADINGS	HECTARES
	468,058	49,980	99,960	0	1700

Feedlots

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	HEAD
RANGE OF TOTAL COSTS FOR FEEDLOTS	366,168 to 636,813	1,734 to 3,468	40,834 to 71,468	1700
RANGE OF TOTAL COSTS FOR AGRICULTURAL NON-POINT SOURCES	834,226 to 1,104,871	51,714 to 53,448	140,794 to 171,428	
RANGE OF TOTAL COSTS FOR SWIMMABLE	2,659,048 to 2,929,693	246,572 to 248,306	530,509 to 561,143	

NOTES TO DETROIT RIVER COSTING TABLES

1. The RAP team had no estimate of how many tonnes of hazardous waste needed to be removed from the area of concern.

2. The RAP team also had no estimate of how many tonnes of sediment needed to be dredged in the river.

3. General Chemical, an inorganic chemical producer was not costed for BAT for removal of toxics because no BAT figures were available.

4. No estimates of agricultural land were available for this site.

5. Apogee estimated all costs associated with achieving all water quality objectives.

SOURCE OF INFORMATION: ALL INFORMATION FROM APOGEE

AESTHETICS

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR AESTHETICS	28,305,410	3,022,500	6,045,000	201500

SWIMMABLE

SOURCE

STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Amherstburg	9,870,832	256,855	1,310,879	Primary	11.7	20.3
Little River	25,004	2,670	5,340	Secondary	43.8	29.6
West Windsor	41,934,654	1,314,460	5,792,314	Primary	126	90.2
TOTAL COSTS FOR STPs	51,830,490	1,573,985	7,108,533			

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	28,305,410	3,022,500	6,045,000	201500
TOTAL COSTS FOR SWIMMABLE	80,135,900	4,596,485	13,153,533	

RAP SITE: DETROIT RIVER

EDIBLE FISHERY				
SOURCE				
Industries				
Metal Moulding	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	FLOW (1000 m^3/d)
Ford Motor Co.	1,489,382	439,294	659,649	71.3
Wickes Manufacturing	54,311	16,019	24,054	2.6
Total	1,543,693	455,313	683,703	
TOTAL COSTS FOR INDUSTRIES	1,543,693	455,313	683,703	
SOURCE				
Urban Runoff				
	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	28,305,410	3,022,500	6,045,000	201500
TOTAL COSTS FOR EDIBLE FISHERY	29,849,103	3,477,813	6,728,703	

RAP SITE: DETROIT RIVER

SPORT FISHERY

SOURCE
STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Amherstburg	9,870,832	256,855	1,310,879	Primary	11.7	20.3
Little River	25,004	2,670	5,340	Secondary	43.8	29.6
West Windsor	41,934,654	1,314,460	5,792,314	Primary	126	90.2
TOTAL COSTS FOR STPs	51,830,490	1,573,985	7,108,533			

SOURCE
Industries

Metal Moulding	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	FLOW (1000 m^3/d)
Ford Motor Co.	1,489,382	439,294	659,649	71.3
Wickes Manufacturing	54,311	16,019	24,054	2.6
Total	1,543,693	455,313	683,703	
TOTAL COSTS FOR INDUSTRIES	1,543,693	455,313	S683,703	

SOURCE
Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	28,305,410	3,022,500	6,045,000	201500
TOTAL COSTS FOR SPORT FISHERY	81,679,593	5,051,798	13,837,236	

NOTES TO HAMILTON HARBOUR COSTING TABLES

1. All cost estimates for remediating Hamilton Harbour were derived by the RAP team except BAT costs for Stelco and Dofasco estimated for achieving an edible fishery and a sport fishery.

2. Operating costs of oxygenation of the harbour range from $52,000 t0 $200,000 or $100,000 to $360,000. The high end of the range was used for the costing tables.

3. The development cost for the sewer use bylaw is a one time cost. The life of capital costs is assumed to be ten years, discounted at ten percent.

4. The cost of sediment removal for the harbour assumes that the contaminated materials can be removed by conventional methods. Costs for sediment removal if the sediments are too contaminated for conventional removal could rise to between 10-20 million dollars.

5. All costs reported by the Hamilton Harbour RAP team were in 1986 dollars. These were multiplied by a factor of 1.082 to reflect current, 1989 dollars.

SOURCE OF INFORMATION: ALL COSTING INFORMATION PROVIDED BY RAP TEAM EXCEPT BAT COSTS FOR STEEL WHICH WERE DERIVED BY APOGEE

AESTHETICS

SOURCE				
STPs	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
Skyway		21,640	21,640	Improved chemical treatment
	16,230,000		1,733,141	Sand filters
Woodward		S59,510	59,510	Improved chemical treatment
	43,280,000		4,621,710	Sand filters
TOTAL COST OF THESE OPTS	59,510,000	81,150	6,436,001	
Action which would preclude above actions				
All STPs	47,608,000	64,920	5,148,583	Divert outflows into Lake Ontario
SOURCE				
Industries	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
Stelco & Dofasco	14,066,000		2,081,077	Recycling of blast furnace gas cleaning water
SOURCE				
Urban Runoff	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
CSOs	64,920,000	0	6,932,268	Retention basin for first flush
Construction Site Erosion	627,560	0	67,012	Stabilization of disturbed areas
TOTAL COSTS FOR URBAN RUNOFF	65,547,560	0	6,999,280	
SOURCE				
Agricultural Non-Point Sources	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
Phosphorus Control	513,950	12,443	67,323	Incorp. reduced and no-till tillage, etc.
Erosion Control		173,120	173,120	Promote cropland erosion controls, etc.
TOTAL COSTS FOR AGRICULTURAL NON-POINT SOURCES	513,950	185,563	240,443	
SOURCE				
Sediment	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
TOTAL COSTS FOR SEDIMENT	2,164,000	0	231,076	Removal of contaminated material
RANGE OF TOTAL COSTS FOR AESTHETICS	129,899,510 to 141,801,510	250,483 to 266,713	14,700,459 to 15,987,877	

RAP SITE: HAMILTON HARBOUR

SWIMMABLE

SOURCE **STPs**	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
Skyway		21,640	21,640	Improved chemical treatment
	16,230,000		1,733,141	Sand filters
Woodward		59,510	59,510	Improved chemical treatment
	43,280,000		4,621,710	Sand filters
TOTAL COST OF THESE OPTS	59,510,000	81,150	6,436,001	
Action which would preclude above actions				
All STPs	47,608,000	64,920	5,148,583	Divert outflows into Lake Ontario

SOURCE **Urban Runoff**	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
CSOs	64,920,00	0	6,932,268	Retention basin for first flush
TOTAL COSTS FOR URBAN RUNOFF	64,920,000	0	6,932,268	

SOURCE **Agricultural Non-Point Sources**	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
Erosion Control		173,120	173,120	Promote cropland erosion controls, etc.
TOTAL COSTS FOR AGRICULTURAL NON-POINT SOURCES	0	173,120	173,120	
RANGE OF TOTAL COSTS FOR SWIMMABLE	112,528,000 to 124,430,000	238,040 to 254,270	12,253,971 to 13,541,389	

RAP SITE: HAMILTON HARBOUR

EDIBLE FISHERY

SOURCE

STPs	DEVELOPMENT COSTS ($)	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	UAC PLUS 1st YEAR DEVELOPMENT COST
Sewer Use-Bylaw	270,500	324,600	1,514,800	1,562,825	1,833,325
TOTAL COSTS FOR SEWER USE BYLAW	270,500	324,600	1,514,800	1,562,825	1,833,325

SOURCE

Industries

Steel	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	FLOW (1000 m^3/d)
Stelco	15,536,938	2,426,452	4,725,156	1046.9
Dofasco	9,518,953	1,486,605	2,894,942	641.4
TOTAL COSTS FOR INDUSTRIES	25,055,891	3,913,057	7,620,098	

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
CSOs	64,920,000	0	6,932,268	Retention basin for first flush
TOTAL COSTS FOR URBAN RUNOFF	64,920,000	0	6,932,268	

SOURCE

Sediment

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
TOTAL COSTS FOR SEDIMENT	2,164,000	0	231,076	Removal of contaminated material
TOTAL COSTS FOR EDIBLE FISHERY	92,734,991	5,427,857	16,346,267	

RAP SITE: HAMILTON HARBOUR

SPORT FISHERY

SOURCE

STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
Skyway		21,640	21,640	Improved chemical treatment
	6,492,000	108,200	801,427	Nitrification
	16,230,000		1,733,141	Sand filters
Woodward		59,510	59,510	Improved chemical treatment
	3,246,000	378,700	725,313	Nitrification
	43,280,000		4,621,710	Sand filters
TOTAL COST OF THESE OPTS	69,248,000	568,050	7,962,741	

STPs ----	DEVELOPMENT COSTS ($)	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	UAC PLUS 1ST YEAR DEVELOPMENT COST
Sewer Use-Bylaw	270,500	324,600	1,514,800	1,562,825	1,833,325

Action which would preclude improved chemical treatment, nitrification, and sand filter options

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
All STPs	47,608,000	64,920	5,148,583	Divert outflows into Lake Ontario

SOURCE

Industries

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
Stelco & Dofasco	14,066,000		2,081,077	Recycling of blast furnace gas cleaning water
				FLOW (1000 m^3/d)
Stelco	15,536,938	2,426,452	4,725,156	1046.9
Dofasco	9,518,953	1,486,605	2,894,942	641.4
TOTAL COSTS FOR INDUSTRIES	39,121,891	3,913,057	9,701,175	

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
CSOs	64,920,000	0	6,932,268	Retention basin for first flush
Construction Site Erosion	627,560	0	67,012	Stabilization of disturbed areas
TOTAL COSTS FOR URBAN RUNOFF	65,547,560	0	6,999,280	

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RAP SITE: HAMILTON HARBOUR

SOURCE **Agricultural Non-Point Sources**	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
Phosphorus Control	513,950	12,443	67,323	Incorp. reduced and no-till tillage, etc.
Erosion Control		173,120	173,120	Promote cropland erosion controls, etc.
TOTAL COSTS FOR AGRICULTURAL NON-POINT SOURCES	513,950	185,563	240,443	

SOURCE **Sediment**	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
TOTAL COSTS FOR SEDIMENT	2,164,000	0	231,076	Removal of contaminated material

MITIGATIVE ACTION **Fish Habitat Enhancement**	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)
Construct berms	10,820	3,246	4,401
Marsh Reconstruction	64,920		6,932
Marsh Restoration	1,082,000	54,100	169,638
Artificial Reefs	173,120	5,410	23,896
Carp Control		86,560	86,560
Pike Planting		16,230	16,230
Oxygenation of Hypolimnion: Air Bubbling OR	4,328,000	216,400	678,551
Oxygen Bubbling	108,200	389,520	401,074
RANGE OF COSTS OF MITIGATION	1,439,060 to 5,658,860	381,946 to 452,276	605,941 to 986,208
RANGE OF TOTAL COSTS FOR SPORT FISHERY	156,989,561 to 182,849,361	6,060,286 to 6,633,746	24,489,323 to 27,683,748

NOTES TO JACKFISH BAY COSTING TABLES

I. There is no farming in the Jackfish Bay water basin so there are no costs for agricultural non-point sources.

2. The issue of whether or not sediment should be removed in Moberly Bay is still being examined. The RAP team will consider dredging if the sediments are found to be contaminated and harming the waterbody.

3. BAT costs for removing toxics from the Kimberly-Clark kraft mill are not available.

4. Urban runoff was the only remedial action costed for Jackfish Bay by Apogee.

RAP SITE: JACKFISH BAY 10/10/89

SOURCE OF INFORMATION: ALL INFORMATION FROM APOGEE

AESTHETICS				
SOURCE				
Urban Runoff	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR AESTHETICS	379,278	40,500	81,000	2700

SWIMMABLE				
SOURCE				
Urban Runoff				
	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR SWIMMABLE	379,278	40,500	81,000	2700

RAP SITE: JACKFISH BAY

EDIBLE FISHERY				
SOURCE				
Urban Runoff				
	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR EDIBLE FISHERY	379,278	40,500	81,000	2700

SPORT FISHERY				
SOURCE				
Urban Runoff				
	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR SPORT FISHERY	379,278	40,500	81,000	2700

NOTES TO METROPOLITAN TORONTO COSTING TABLES

1. Estimation of reducing phosphorus from feedlots using best management practices is from the MTRCA.

2. No cost estimates were available for Mimico Creek.

3. All costs estimated in the TAWMS and Stage 1 documents have been converted to 1989 dollars.

SOURCE OF INFORMATION: TAWMS document for Humber and Don Rivers costing for phosphorus removal from feedlots, MTRCA RAP, Stage 1 Document

AESTHETICS

SOURCE
Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
Don River	88,000,000 to 109,300,000	12,000,000 to 15,000,000	21,400,000 to 26,700,000	Don River cleanup strategy
Humber River	5,400,000		576,621	CSO control
	18,684,000		1,995,109	Flood reduction - York
	3,996,000		426,700	Catch basin cleaning
Other	6,420,000		685,539	Flood reduction - East York
	12,600,000		1,345,449	COO control - Scarborough
	39,900,000		4,260,590	CSO control - Metro
	13,910,000		1,485,334	Detention tanks - Eastern Beaches
	963,000		102,831	Centre Island diffuser
RANGE OF TOTAL COSTS FOR AESTHETICS	189,873,000 to 211,173,000	12,000,000 to 15,000,000	32,278,173 to 37,578,173	

SWIMMABLE

SOURCE
Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
Don River	328,600,000 to 375,600,000	45,000,000 to 56,000,000	80,088,469 to 96,107,209	Don River cleanup strategy
Humber River	5,400,000		576,621	CSO control
	18,684,000		1,995,109	Flood reduction - York
	3,996,000		426,700	Catch basin cleaning
	7,128,000		761,140	Sanitary connections
Other	6,420,000		685,539	Flood reduction - East York
	12,600,000		1,345,449	CSO control - Scarborough
	39,900,000		4,260,590	CSO control - Metro
	13,910,000		1,485,334	Detention tanks - Eastern Beaches
	963,000		102,831	Centre Island diffuser
	47,250,000		5,045,436	New outfall for Main STP
	61,950,000	9,030,000	15,645,127	North Toronto STP
RANGE OF TOTAL COSTS FOR SWIMMABLE	546,801,000 to 593,801,000	54,030,000 to 65,030,000	112,418,345 to 128,437,085	

RAP SITE: METRO TORONTO

		EDIBLE FISHERY		
SOURCE				
Urban Runoff				
	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
Don River	328,600,000	45,000,000	80,008,469	Don River cleanup strategy
	to	to	to	
	375,600,000	56,000,000	96,107,209	
Humber River	5,400,000		576,621	CSO control
	18,684,000		1,995,109	Flood reduction - York
	3,996,000		426,700	Catch basin cleaning
	7,128,000		761,140	Sanitary connections
	1,404,000		149,922	Stormwater ponds
Other	6,420,000		685,539	Flood reduction - East York
	12,600,000		1,345,449	CSO control - Scarborough
	39,900,000		4,260,590	CSO control- Metro
	13,910,000		1,485,334	Detention tanks - Eastern Beaches
	963,000		102,831	Centre Island diffuser
TOTAL COSTS FOR EDIBLE FISHERY	439,005,000	45,000,000	91,877,704	
	to	to	to	
	486,005,000	56,000,000	107,896,444	

RAP SITE: METRO TORONTO

SPORT FISHERY

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	ACTION
Don River	328,600,000 to 375,600,000	45,000,000 to 56,000,000	80,088,469 to 96,107,209	Don River cleanup strategy
Humber River	5,400,000		576,621	CSO control
	18,684,000		1,995,109	Flood reduction - York
	7,128,000		761,140	Dry weather sources
Other	6,420,000		685,539	Flood reduction - East York
	12,600,000		1,345,449	CSO control - Scarborough
	39,900,000		4,260,590	CSO control - Metro
	13,910,000		1,485,334	Detention tanks - E. Beaches
	963,000		102,831	Centre Island diffuser
	47,250,000		5,045,436	New outfall for Main STP
	61,950,000	8,600,000	15,215,127	North Toronto SIP
RANGE OF TOTAL COSTS FOR URBAN RUNOFF	542,805,000 to 589,805,000	53,600,000 to 64,600,000	111,561,645 to 127,580,385	

SOURCE

Agricultural Non-Point Sources

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	LOADINGS	HECTARES
	26,097,521	2,786,738	5,573,476	0	94787

Feedlots

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)
RANGE OF TOTAL COSTS FOR FEEDLOTS	500,000 to 1,000,000		53,391 to 106,782
RANGE OF TOTAL COSTS FOR AGRICULTURAL NON-POINT SOURCES	26,597,521 to 27,097,521	2,786,738	5,626,867 to 5,680,258
RANGE OF TOTAL COSTS FOR SPORT FISHERY	569,402,521 to 616,902,521	56,386,738 to 67,386,738	117,188,512 to 133,260,643

NOTES TO NIAGARA RIVER COSTING TABLES

1. No estimates of feedlots or agricultural land in the Niagara River water basin are currently available, thus no cost estimates were made.

2. Tonnes of hazardous waste which need to be disposed of has not yet been estimated by the RAP team.

3. Tonnes of sediment to be dredged in currently being examined by the RAP team. No estimates were available to the consultants.

4. All of the cost estimates for the Niagara River were derived by Apogee.

SOURCE OF INFORMATION: ALL INFORMATION FROM APOGEE

AESTHETICS

SOURCE
Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR AESTHETICS	23,754,069	2,536,500	5,073,000	169100

SWIMMABLE

SOURCE
STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Niagara Falls	26,353,768	709,407	3,523,507	Primary	56.76	38.15
Fort Erie	8,992,265	203,893	1,164,102	Primary	10.8	8.8
TOTAL COSTS FOR STPs	35,346,033	913,300	4,687,609			

SOURCE
Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	23,754,069	2,536,500	5,073,0001	69100
TOTAL COSTS FOR SWIMMABLE	59,100,102	3,449,800	9,760,609	

RAP SITE: NIAGARA RIVER

EDIBLE FISHERY				
SOURCE				
Industries				
Steel	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	FLOW (1000 m^3/d)
Atlas Steel	456,358	71,271	138,790	30.75
Metal Moulding				FLOW (1000 m^3/d)
Fleet Manufacturing	21,307	6,284	9,436	1.02
Stelpipe Tube Works	8,272	2,440	3,664	0.396
Total	29,579	8,724	13,100	
Organic Chemicals				FLOW (1000 m^3/d)
Cyanamid (Welland)	3,335,735	1,072,845	1,566,370	24.7
Cyanamid (Niagara Falls)	4,375,620	1,407,294	2,054,671	32.4
Total	7,711,355	2,480,139	3,621,041	
TOTAL COSTS FOR INDUSTRIES	8,197,292	2,560,134	3,772,931	
SOURCE				
Urban Runoff				
	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	23,754,069	2,536,500	5,073,000	169100
TOTAL COSTS FOR EDIBLE FISHERY	31,951,361	5,096,634	8,845,931	

RAP SITE: NIAGARA RIVER

SPORT FISHERY

SOURCE
STPS

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Niagara Falls	26,353,768	709,407	3,523,507	Primary	56.76	38.15
Fort Erie	8,992,265	203,893	1,164,102	Primary	10.8	8.8
TOTAL COSTS FOR SIPS	35,346,033	913,300	4,687,609			

SOURCE
Industries

Steel	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	FLOW (1000 m^3/d)
Atlas Steel	456,358	71,271	138,790	30.75
Metal Moulding				FLOW (1000 m^3/d)
Fleet Manufacturing	21,307	6,284	9,436	1.02
Stelpipe Tube Works	8,272	2,440	3,664	0.396
Total	29,579	8,724	13,100	
Organic Chemicals				FLOW (1000 m^3/d)
Cyanamid (Welland)	3,335,735	1,072,845	1,566,370	24.7
Cyanamid (Niagara Falls)	4,375,620	1,407,294	2,054,671	32.4
Total	7,711,355	2,480,139	3,621,041	
TOTAL COSTS FOR INDUSTRIES	8,197,292	2,560,134	3,772,931	

SOURCE
Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	23,754,069	2,536,500	5,073,000	169100
TOTAL COSTS FOR SPORT FISHERY	67,297,394	6,009,934	13,533,540	

NOTES TO NIPIGON BAY COSTING TABLES

1. There is no agricultural land uses in the Nipigon Bay watershed.

2. Sediments in the area have not yet been examined. If there is found to be a problem with the sediments, they will be removed.

3. Domtar pulp and paper mill discharges into the bay. Toxics removal were not costed as BAT estimates were not available.

4. Apogee estimated the costs for urban runoff and STP upgrade for the Red Rock STP.

RAP SITE: NIPIGON 10/13/89

SOURCE OF INFORMATION: ALL INFORMATION FROM APOGEE

AESTHETICS

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR AESTHETICS	547,847	58,500	117,000	3900

SWIMMABLE

SOURCE

STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Red Rock	1,741,672	67,130	253,109	Primary	0.745	2.258
TOTAL COSTS FOR STPs	1,741,672	67,130	253,109			

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	547,847	58,500	117,000	3900
TOTAL COSTS FOR SWIMMABLE	2,289,519	125,630	370,109	

RAP SITE: NIPIGON

EDIBLE FISHERY

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR EDIBLE FISHERY	547,847	58,500	117,000	3900

SPORT FISHERY

SOURCE

STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING. (kg/d)
Red Rock	1,741,672	67,130	253,109	Primary	0.745	2.258
TOTAL COSTS FOR STPs	1,741,672	67,130	253,109			

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	547,847	58,500	117,000	3900
TOTAL COSTS FOR SPORT FISHERY	2,289,519	125,630	370,109	

NOTES TO PENINSULA HARBOUR COSTING TABLES

1. The only remedial action costed for Peninsula Harbour by Apogee was additional phosphorus removal from the Marathon STP.

2. There is sediment contaminated with mercury in Peninsula Harbour. Dredging the sediments is one option for removal, however if this is done, toxics in sediments may be resuspended and thus make the water quality problem worse. The RAP team is currently examining the problem and were not able to estimate the area of sediments to be removed if this option were chosen.

SOURCE OF INFORMATION: ALL INFORMATION FROM APOGEE

SPORT FISHERY						
SOURCE **STPs**						
	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Marathon	202,783	21,654	43,307	Secondary	1.129	5
TOTAL COSTS FOR STPs	202,783	21,654	43,307			
TOTAL COSTS FOR SPORT FISHERY	202,783	21,654	43,307			

NOTES TO PORT HOPE HARBOUR COSTING TABLES

1. The RAP team is examining many ways of remediating the contaminated sediment in Port Hope harbour. Dredging and capping have both been costed for the harbour. Dredging costs were provided by the RAP team. These costs were estimated by MacLaren Engineers, Canadian Dredging and Docking Inc, and Golder Associates in 'Port Hope Remedial Program - Conceptual Engineering Design for Harbour Clean-Up" while Apogee estimated the costs of capping from information provided by the U.S. Army Corp of Engineers.

2. The costs of capping estimated by Apogee assume that the area to be capped is 30,000 square metres and is one metre deep. In order to cover this area with one metre deep of sediment, 90,000 m^3 of dredged material would have to be moved and placed on top to form the cap.

RAP SITE: PORT HOPE 25/01/90

SOURCE OF INFORMATION: CAPPING INFORMATION FROM APOGEE
DREDGING INFORMATION FROM MACLAREN ENGINEERS, CANADIAN DREDGING & DOCKING INC., AND GOLDER ASSOCIATES, 1987
PORT HOPE REMEDIAL PROGRAM - CONCEPTUAL ENGINEERING DESIGN FOR HARBOUR CLEAN-UP

AESTHETICS					
SOURCE					
Sediment					
	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	VOLUME	AREA
RANGE OF TOTAL COSTS FOR SEDIMENT CAPPING	900,000 to 1,350,000		96,104 to 144,155	90000	0
OR					
RANGE OF TOTAL COSTS FOR SEDIMENT DREDGING	1,542,450 to 6,090,000		164,705 to 650,301		

NOTES TO ST. CLAIR RIVER COSTING TABLES

I. The St. Clair River has a number of hazardous waste sites which need some level of treatment. At this time however, there are no estimates of hazardous waste to be treated, or sediment to be removed currently available.

2. Inorganic BAT costs for CIL are also not available.

3. Costs for the four industries in the organic chemical sector are based on flow. After confirmation by two Ministry officials, it was assumed that the flows given in the MOE Report on the 1987 Industrial Direct Dischargers were process flows and not total flows. Costs would decrease dramatically for these industries if the flow figures in the Report were assumed to be total flow figures.

4. Urban Runoff, STP upgrading from primary to secondary with advanced phosphorus removal, industrial toxic effluent removal, and agricultural non-point source removal were all estimated by Apogee.

SOURCE OF INFORMATION: ALL INFORMATION FROM APOGEE

AESTHETICS

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR AESTHETICS	11,013,122	1,176,000	2,352,000	78400

SWIMMABLE

SOURCE

STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Sarnia	25,892,600	705,448	3,470,304	Primary	54.6	47.3
Point Edward	2,971,330	100,357	417,641	Primary	1.74	3.23
TOTAL COSTS FOR STPS	28,863,930	805,805	3,887,945			

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	11,013,122	1,176,000	2,352,000	78400
TOTAL COSTS FOR SWIMMABLE	39,877,052	1,981,805	6,239,945	

RAP SITE: ST. CLAIR RIVER

EDIBLE FISHERY				
SOURCE				
Industries				
Organic Chemicals	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	FLOW (1000 m^3/d)
Polysar Sarnia	39,367,075	12,661,303	18,485,696	291.5
Petrosar Coruna	850,815	273,641	399,520	6.3
Dow Chemical	98,437,945	31,659,772	46,223,753	728.9
Ethyl Canada	4,491,763	1,444,648	2,109,208	33.26
Total	143,147,598	46,039,364	67,218,177	
TOTAL COSTS FOR INDUSTRIES	143,147,598	46,039,364	67,218,177	
SOURCE				
Urban Runoff				
	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	11,013,122	1,176,000	2,352,000	78400
TOTAL COSTS FOR EDIBLE FISHERY	154,160,720	47,215,364	69,570,177	

SPORT FISHERY

SOURCE
STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Sarnia	25,892,600	705,448	3,470,304	Primary	54.6	47.3
Point Edward	2,971,330	100,357	417,641	Primary	1.74	3.23
TOTAL COSTS FOR STPs	28,863,930	805,805	3,887,945			

SOURCE
Industries

Organic Chemicals	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	FLOW (1000 m^3/d)
Polysar Sarnia	39,367,075	12,661,303	18,485,696	291.5
Petrosar Corunna	850,815	273,641	399,520	6.3
Dow Chemical	98,437,945	31,659,772	46,223,753	728.9
Ethyl Canada	4,491,763	1,444,648	2,109,208	33.26
Total	143,147,598	46,039,364	67,218,177	
TOTAL COSTS FOR INDUSTRIES	143,147,598	46,039,364	67,218,177	

SOURCE
Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	11,013,122	1,176,000	2,352,000	78400

SOURCE
Agricultural Non-Point Sources

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	LOADINGS	HECTARES
Farmland	5,781,889	617,400	1,234,800	0	21000
TOTAL COSTS FOR AGRICULTURAL NON- POINT SOURCES	5,781,889	617,400	1,234,800		
TOTAL COSTS FOR SPORT FISHERY	188,806,539	48,638,569	74,692,922		

NOTES TO ST. LAWRENCE RIVER COSTING TABLES

1. No estimates of amount of sediment to be dredged are available for the Canadian side of the border.

2. Estimates for farmland and head of livestock were derived as "first cut" estimates by the Glengarry Soil and Crop Improvement Association.

3. Secondary treatment costs for Domtar have been estimated by the MOE, Cornwall to be 10-15 Million Dollars. MOE has also estimated $5 million for zinc removal at Courtaulds and $10 million for secondary treatment.

4. MOE costs of remediation for Cornwall Chemicals is $300,000, significantly higher than Apogee BAT estimates.

RAP SITE: ST. LAWRENCE RIVER 10/13/89

SOURCE OF INFORMATION: DOMTAR FLOW, MOE
ACREAGE & DAIRY CATTLE, GLENGARRY ASSOCIATION

AESTHETICS

SOURCE
Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR AESTHETICS	9,060,541	967,500	1,935,000	64500

SWIMMABLE

SOURCE
STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
City of Cornwall	22,615,075	602,441	3,017,317	Primary	43.68	44.3
TOTAL COSTS FOR SIPS	22,615,075	602,441	3,017,317			

SOURCE
Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	9,060,541	967,500	1,935,000	64500
TOTAL COSTS FOR SWIMMABLE	31,675,616	1,569,941	4,952,317	

RAP SITE: ST. LAWRENCE RIVER

EDIBLE FISHERY				
SOURCE				
Industries				
Organic Chemicals	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	FLOW (1000 m^3/d)
CIL	426,758	137,250	200,394	3.16
Cornwall Chemicals	81,030	26,061	38,049	0.6
Courtaulds	1,643,559	528,604	771,770	12.17
TOTAL COSTS FOR INDUSTRIES	2,151,347	691,920	1,010,213	
SOURCE				
Urban Runoff				
	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	9,060,541	967,500	1,935,000	64500
TOTAL COSTS FOR EDIBLE FISHERY	11,211,888	1,659,420	2,945,213	

RAP SITE: ST. LAWRENCE RIVER

SPORT FISHERY

SOURCE
STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
City of Cornwall	22,615,075	602,441	3,017,317	Primary	43.68	44.3
TOTAL COSTS FOR STPs	22,615,075	602,441	3,017,317			

SOURCE
Industries

Organic Chemicals	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	FLOW (1000 m^3/d)
CIL	426,758	137,255	200,394	3.16
Cornwall Chemicals	81,030	26,061	38,049	0.6
Courtaulds	1,643,559	528,604	771,770	12.17
TOTAL COSTS FOR INDUSTRIES	2,151,347	691,920	1,010,213	

SOURCE
Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	9,060,541	967,500	1,935,000	64500

SOURCE
Agricultural Non-Point Sources

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	LOADINGS	HECTARES
Intensive row cropping	2,228,505	237,964	475,927	0	8094

Feedlots

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	HEAD
RANGE OF	4,307,854	20,400	480,400	20000
TOTAL COSTS	to	to	to	
FOR FEEDLOTS	7,491,920	40,800	840,800	
RANGE OF TOTAL COSTS FOR	6,536,359	258,364	956,327	
AGRICULTURAL	to	to	to	
NON-POINT SOURCES	9,720,425	278,764	1,316,727	
RANGE OF TOTAL	40,363,322	2,520,225	6,918,857	
COSTS FOR	to	to	to	
SPORT FISHERY	43,547,388	2,540,625	7,279,257	

NOTES TO ST. MARYS RIVER COSTING TABLES

1. There are no estimates of hazardous waste to be treated, or sediment to be removed currently available.

2. The agricultural area in the drainage basin and the head of livestock are currently being examined by the RAP team.

3. Costs of BAT for St. Marys Paper were not available.

4. Apogee estimated all costs of remediating the St. Marys River. This included estimating remediation of urban runoff, upgrading the Sault Ste. Marie STP from primary to secondary with additional phosphorus removal, upgrading the Ontario West End STP from secondary to secondary with additional phosphorus removal, and BAT cost for Algoma Steel.

SOURCE OF INFORMATION: ALL INFORMATION FROM APOGEE

AESTHETICS

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR AESTHETICS	11,884,058	1,269,000	2,538,000	84600

SWIMMABLE

SOURCE

STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Ontario East End:						
Sault Ste. Marie	20,844,742	718,037	2,943,874	Primary	32.04	108.1
Ontario West End	37,450	3,999	7,998	Secondary	6.65	5.4
TOTAL COSTS FOR SIPS	20,882,192	722,036	2,951,872			

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	11,884,058	1,269,000	2,538,000	84600
TOTAL COSTS FOR SWIMMABLE	32,766,250	1,991,036	5,489,872	

RAP SITE: ST. MARYS RIVER

EDIBLE FISHERY				
SOURCE				
Industries				
Steel	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	FLOW (1000 m^3/d)
Algoma Steel	7,218,243	1,127,296	2,195,241	486.375
TOTAL COSTS FOR INDUSTRIES	7,218,243	1,127,296	2,195,241	
SOURCE				
Urban Runoff				
	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	11,884,058	1,269,000	2,538,000	84600
TOTAL COSTS FOR EDIBLE FISHERY	19,102,301	2,396,296	4,733,241	

RAP SITE: ST. MARYS RIVER

SPORT FISHERY

SOURCE
STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Ontario East End:						
Sault Ste. Marie	20,844,742	718,037	2,943,874	Primary	32.04	108.1
Ontario West End	37,450	3,999	7,998	Secondary	6.65	5.4
TOTAL COSTS FOR STPs	20,882,192	722,036	2,951,872			

SOURCE
Industries

Steel	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	FLOW (1000 m^3/d)
Algoma Steel	7,218,243	1,127,296	2,195,241	486.375
TOTAL COSTS FOR INDUSTRIES	7,218,243	1,127,296	2,195,241	

SOURCE
Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	11,884,058	1,269,000	2,538,000	84600
TOTAL COSTS FOR SPORT FISHERY	39,984,493	3,118,332	7,685,113	

NOTES TO SEVERN SOUND COSTING TABLES

1. Mitsubishi was not costed for tonics removal because it is already a state-of-the-art plant.

2. A small amount of sediments may have to be dredged in Penetang Harbour. These sediments are high in nutrients which may be feeding into the water column.

3. Apogee estimated the costs of additional phosphorus removal for four STPs. Urban runoff and sediment removal was also estimated by Apogee.

RAP SITE: SEVERN SOUND 10/11/89

SOURCE OF INFORMATION: AREA FOR SEDIMENT DREDGING FROM MOE
ALL OTHER COSTING INFORMATION FROM APOGEE

AESTHETICS

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR AESTHETICS	5,113,235	546,000	1,092,000	36400

SWIMMABLE

SOURCE

STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Port McNicol	2,126	227	454	Secondary	0.653	0.373
Cold Water	47,958	5,121	10,242	Secondary	0.372	1.235
Elmvale	118,776	12,683	25,366	Secondary	1.124	3.16
Midland	9,871	1,054	2,108	Secondary	11.15	6.915
TOTAL COSTS FOR STPs	178,731	19,085	38,170			

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	5,113,235	546,000	1,092,000	36400
TOTAL COSTS FOR SWIMMABLE	5,291,966	565,085	1,130,170	

RAP SITE: SEVERN SOUND

EDIBLE FISHERY

SOURCE
Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	5,113,235	546,000	1,092,000	36400

SOURCE
Sediment

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	VOLUME	AREA
RANGE OF	325,000		34,704	0	5000
TOTAL COSTS	to		to		
FOR SEDIMENT	2,250,000		240,259		
RANGE OF TOTAL	5,438,235		1,126,704		
COSTS FOR	to		to		
EDIBLE FISHERY	7,363,235	546,000	1,332,259		

RAP SITE: SEVERN SOUND

SPORT FISHERY

SOURCE
STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Port McNicol	2,126	227	454	Secondary	0.653	0.373
Cold Water	47,958	5,121	10,242	Secondary	0.372	1.235
Elmvale	118,776	12,683	25,366	Secondary	1.124	3.160
Midland	9,871	1,054	2,108	Secondary	11.15	6.915
TOTAL COSTS FOR STPs	178,731	19,085	38,170			

SOURCE
Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	5,113,235	546,000	1,092,000	36400

SOURCE
Sediment

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	VOLUME	AREA
RANGE OF TOTAL COSTS FOR SEDIMENT	325,000 to 2,250,000		34,704 to 240,259	0	5000
RANGE OF TOTAL COSTS FOR SPORT FISHERY	5,616,966 to 7,541,966	565,085	1,164,874 to 1,370,429		

NOTES TO SPANISH RIVER COSTING TABLES

I. E.B. Eddy was not costed for toxics removal because there is no problem with the edible fishery at this site.

2. Apogee estimated the costs of upgrading the STP from primary to secondary with additional phosphorus removal.

SOURCE OF INFORMATION: ALL INFORMATION FROM APOGEE

SWIMMABLE

SOURCE **STPs**	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Espanola	4,765,081	184,862	693,685	Primary	3.09	14
TOTAL COSTS FOR STPs	4,765,081	184,862	693,685			
TOTAL COSTS FOR SWIMMABLE	4,765,081	184,862	693,685			

NOTES TO THUNDER BAY COSTING TABLES

1. Dredging which needs to be done is in front of Northern Wood Preservers.

2. Industries which were not costed for toxic removal because of a lack of BAT costs are Great Lakes Forest Products, Northern Wood Preservers, and Abitibi-Price Provincial Paper Division, Fort William Division, and Thunder Bay Division.

3. All cost estimates of upgrading the Thunder Bay STP, urban runoff, and sediment removal were derived by Apogee.

SOURCE OF INFORMATION: INFORMATION ON SEDIMENT VOLUME FROM MOE
ALL COSTS ESTIMATES MADE BY APOGEE

AESTHETICS

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR AESTHETICS	17,193,956	1,836,000	3,672,000	122400

SWIMMABLE

SOURCE

STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Thunder Bay	32,777,495	948,207	4,448,244	Primary	81.1	74.52
TOTAL COSTS FOR STPs	32,777,495	948,207	4,448,244			

SOURCE

Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	17,193,956	1,836,000	3,672,000	122400
TOTAL COSTS FOR SWIMMABLE	49,971,451	2,784,207	8,120,244	

RAP SITE: THUNDER BAY

EDIBLE FISHERY				
SOURCE				
Urban Runoff				
	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	17,193,956	1,836,000	3,672,000	122400
SOURCE				
Sediment				
RANGE OF TOTAL COSTS FOR SEDIMENT	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	VOLUME(m^3)
Assume 54 µg/g total PAH	4,810,000		513,620	74000
	to		to	
	33,300,000		3,555,831	
Assume 2000 µg/g of hexane extractables	4,355,000		465,034	67000
	to		to	
	30,150,000		3,219,468	
Assume 5000 µg/g of hexane extractables	1,300,000		138,816	20000
	to		to	
	9,000,000		961,035	
RANGE OF TOTAL COSTS FOR SEDIMENT REMOVAL	1,300,000 to 33,300,000		138,816 to 3,555,831	
RANGE OF TOTAL COSTS FOR EDIBLE FISHERY	18,493,956 to 50,493,956	1,836,000	3,810,816 to 7,227,831	

RAP SITE: THUNDER BAY

SPORT FISHERY

SOURCE
STPs

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	CURRENT TYPE OF TREATMENT	FLOW (1000 m^3/d)	LOADING (kg/d)
Thunder Bay	32,777,495	948,207	4,448,244	Primary	81.1	74.52
TOTAL COSTS FOR STPs	32,777,495	948,207	4,448,244			

SOURCE
Urban Runoff

	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	POPULATION
TOTAL COSTS FOR URBAN RUNOFF	17,193,956	1,836,000	3,672,000	122400

SOURCE
Sediment

RANGE OF TOTAL COSTS FOR SEDIMENT	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)	VOLUME (m"3)
Assume 54 µg/g total PAH	4,810,000 to 33,300,000		513,620 to 3,555,831	74000
Assume 2000 µg/g of hexane extractables	4,355,000 to 30,150,000		465,034 to 3,219,468	67000
Assure 5000 µg/g of hexane extractables	1,300,000 to 9,000,000		138,816 to 961,035	20000
RANGE OF TOTAL COSTS FOR SEDIMENT REMOVAL	1,300,000 to 33,300,000		138,816 to 3,555,831	
RANGE OF TOTAL COSTS FOR SPORT FISHERY	51,271,451 to 83,271,451	2,784,207	8,259,060 to 11,676,075	

NOTES TO WHEATLEY HARBOUR COSTING TABLES

1. Capital costs for treating the bacteria in Omstead Foods effluent via ultra violet treatment were provided by the RAP coordinator. Operating costs (electricity rates) were provided by Ontario Hydro. Electricity rates used were $5.20/KW/month. Energy costs were estimated to be 17.5 cents per month.

RAP SITE: WHEATLEY HARBOUR 25/01/90

SOURCE OF INFORMATION: ALL INFORMATION FROM RAP COORDINATOR

	SWIMMABLE		
SOURCE			
Industries			
Food and Beverage	TOTAL CAPITAL ($)	ANNUAL O&M ($)	UAC ($)
Omstead Foods	86,000	900 to 1,600	13,624 to 14,324
RANGE 0F TOTAL COSTS FOR SWIMMABLE	86,000	900 to 1,600	13,624 to 14,324

Note:
Costs of ultra-violet treatment are estimates to remove bacteria for swimming purposes.

APPENDIX B

COST ESTIMATION METHODOLOGY FOR REMEDIATION ACTIVITIES

COST ESTIMATION METHODOLOGY FOR REMEDIATION ACTIVITIES

The approach followed in estimating remediation costs at each RAP site was to determine whether or not the RAP team had already prepared cost estimates for the identified remediation activities. If the RAP team had done so, then their cost estimates were used in the analysis.

If this information was not available from the RAP team or other local sources, then Canadian and U.S. sources were used to obtain estimates of the remediation costs encountered in similar circumstances elsewhere.

There were six types of sources of pollutants for which remedial costs had to be estimated:

1. *sewage treatment plants* affecting the waterbody;
2. *industrial point sources* of pollutants;
3. *urban runoff into the affected* area;
4. *agricultural non-point source runoff* into the area;
5. *contaminated sediments* already deposited into the areas of concern; and
6. *toxic waste sites* that were leaking into the areas of concern.

The cost estimation methodology used far each of these sources is discussed below.

I. SEWAGE TREATMENT PLANTS

Sewage treatment plants represent one of the most common sources of pollution in all 17 of the areas of concern. Considerable effort was spent on finding a reliable source of information on costs of remediating the effluents of these plants.

Both Canadian and U.S. sources were examined. In the final analysis, two U.S. sources were used, both published by the U.S. Environmental Protection Agency (EPA):

1) cost curves for a wide variety of treatment components to estimate the cost of upgrading a primary treatment facility to an advanced secondary treatment level with nutrient removal (BOD_5 of 24 mg/L or less, and

phosphorus of 3 mg/L); and

2) survey data on advanced phosphorus removal to effluent concentrations of less than 1 mg/L.

The 1987 protocol of the Great Lakes Water Quality Agreement requires that all STPs in the lower Great Lakes with flow rates of 1 million gallon per day or greater reduce their phosphorus effluent concentration to 0.5 mg/L.

Secondary treatment is likely to reduce the outflow loading of toxic constituents from an STP. However, treatment techniques to eliminate toxics and industrial pretreatment of toxics before they reach an STP are not included in the described cost estimates. The costs of pre-treating indirect discharges are industry specific. These costs could be estimated from U.S. EPA data if information on the number and type of indirect dischargers of toxics were available. However, to date, Ontario is concentrating on direct dischargers via its MISA program.

Upgrade from Primary Treatment to Advanced Secondary Treatment with Nutrient Removal

U.S. EPA (1979, 1980) has developed cost curves for different sizes, components, and treatment levels for sewage treatment plants. Such unit cost equations are formulated as a function of throughput in dollars per 1000 m^3 or millions of gallons per day treated. "First order" costs, defined as total average plant costs for different sizes of plants, are used for estimating the costs of upgrading from primary to "advanced secondary treatment with nutrient removal' (defined as BOD of 11 mg/L to 24 mg/L and reduction of total phosphorus to 3.0 mg/L or less and ammonia nitrogen to 5.0 mg/L or less), Capital cost curves *for* upgrading from primary and secondary treatment to secondary and more advanced levels of treatment are in Figure 1 on the reverse page.

The "advanced secondary" treatment level for the upgrade from primary treatment was selected rather than the "secondary' treatment level because advanced secondary includes nutrient removal measures (to levels described above). The cost equation for upgrade from primary to advanced secondary treatment is Curve 2 in Figure 1:

$$\text{Cost (\$)} = 2.76 \times 10^6 \times Q^{0.75}$$

where Q is plant flow in millions of gallons per day (MGD).

Since this equation estimates the cost of new plant construction of advanced secondary treatment , costs for the existing primary treatment plant must be deducted. The cost deduction for an existing primary treatment plant is Curve A in Figure 1:

$$3.32 \times 10^{5} \times Q^{1.08},$$

where Q is plant flow in MGD.

Plant flow in metric units (1000 m^3 per day) are converted into MGD. As 1 gallon = 3.785 litres, 1 MGD = 3.785 1000 m^3 per day. In summary, the capital cost of an upgrade from primary to advanced secondary is Curve 2 - Curve A.

Cost curves *for* calculating the incremental operation and maintenance (O&M) cost increase from primary to advanced secondary treatment have not been calculated by U.S. EPA. We have therefore taken one half of the advanced secondary treatment O&M costs as an estimate of the incremental O&M cost. Therefore,

$$O\&M = \tfrac{1}{2} \times 1.03 \times 10^{5} \times Q^{0.776}$$

where Q is plant flow.

Costs are translated into 1989 Canadian dollars using cost indices developed by the U.S. Department of Commerce's Bureau of Economic Analysis (BEA) specifically for water pollution control costs (multiplicative factor of 1.5 for 1979 capital costs and a factor of 1.4 for 1980 O&M costs). A September 1, 1989 exchange rate of US$0.85 to C$1.00 is used to convert United States dollars to Canadian dollars.

Phosphorus Removal to Effluent Concentration of 0.5 mg/L Total Phosphorus

U.S. EPA's cost curves for sewage treatment are based on survey of STPs in the 1970s. The costs do not include advanced phosphorus removal (below 3.0 mg/L). U.S. EPA (1989) recently published survey data of 26 small sewage treatment plants in the Great Lakes area (U.S. EPA Region V) specifically undergoing upgrading for advanced phosphorus removal (less than 1 mg/L). In addition, the EPA study reported on the cost-effectiveness of advanced phosphorus removal estimated for U.S. EPA by SAIC (a consulting company) for 23 larger STPs in the Great Lakes Basin. The U.S. EPA and SAIC's findings (see Table 1), expressed in terms of cost effectiveness of phosphorus removal, are used to estimate the cost of reducing phosphorus to 0.5 mg/L (converted from the 1985 US dollars used in the EPA and SAIC studies into 1989 Canadian dollars per kg of phosphorus removed using BEA indexes and 0.85 exchange rate).

TABLE 1. Cost Effectiveness Of Phosphorus Removal To Effluent Concentrations Of Less Than 1 Mg/L Total Phosphorus.

Facility size (mgd)	Facility size (1000 m^3/day)	Cost-effectiveness (1989 C$/kg/yr)
less than 0.5	less than 1.9	26.75
0.5 - 1.9	1.9 - 7.5	10.56
2.0 - 4.9**	7.5 - 18.6	4.31
5.0 - 9.9	18.6 -37.5	3.47
10.0 - 19.9	37.5 - 75.4	1.90
20.0 & up	75.4 & up	1.15

** 2.0 to 4.9 mgd range based on composite of EPA and SAIC studies
Source: U.S. EPA 1989

Table 1 data are used to estimate the cost of advanced phosphorus removal at STPs in RAP areas. The amount of phosphorus reduction required to meet an average effluent of 0.5 mg/L will be calculated for each plant and then multiplied by the cost factor to derive total annual costs. One half of the annualized costs is assumed to be O&M costs, the other half annualized capital costs (a rule-of-thumb for dividing annualized cost figures). Present value of capital costs are derived by discounting the capital costs over a 20 year capital recovery period at a discount rate of 10 percent.

2. INDUSTRIAL POINT SOURCES

The primary concern with industrial point sources in this study is the toxic pollutants contained in the effluents.

As pointed out in the introduction to the report, there is little scientific knowledge available about the relationship between toxics in effluents and the resulting accumulation of toxics in fish tissues. So the question arises: what level of reduction of toxics in the effluents must be achieved in order to eliminate the toxics from the local fish?

The assumption made in this study was that bringing the effluents into line with Provincial toxics guidelines would accomplish the goal of eliminating the toxics from the fish. However, Ontario, through its MISA program, is in the midst of developing effluent standards for the major direct industrial dischargers into the Provincial waterways. The effluent monitoring phase is under way for the major industrial sectors, and it is expected that effluent guidelines will be set over the next few years. Thus, while it would be wrong to use existing Ontario regulations, it is not known what limits will be set under MISA.

The approach taken in the face of this difficulty was to rely on the industrial pollution abatement estimates provided by the U.S. Environmental Protection Agency.

U.S. EPA "development documents" describing an industry and its pollution control options and "economic impact analyses" of best available technology (BAT) are among the best sources of information on the cost of control and abatement of toxic contaminants in industrial wastewater effluents. BAT standards were developed by U.S. EPA following the 1977 amendments to the U.S. Clean Water Act. EPA's economic impact analyses calculated capital and annualized costs of industry compliance with BAT regulations. Annual operating costs are not listed separately.

The costs of implementing U.S. BAT regulations will be taken as a proxy for the industry costs of implementing control of toxic pollutants in Ontario such as that planned by the MISA program. It is highly likely that the MISA program will call for more stringent regulations than those in the EPA's BAT, and thus, this approach probably underestimates the costs of remediating the industrial effluents.

The type of cost estimate used for the RAP study is industry specific due to the various methods U.S. EPA used in its cost estimation procedures and due to differences between industrial processes.

The BAT standards will likely give a lower bound on the MISA compliance costs or the costs of eliminating toxic effluents that prevent the achievement of an edible fishery. MISA is likely to introduce standards more stringent than U.S. BAT standards in some cases.

The U.S. BAT costs are the costs of industry compliance and do not include government administrative and enforcement costs.

Some industries and some toxics emitted by some industries are not yet covered by U.S. BAT standards. BAT standards do not yet exist for pesticide manufacturing and for dioxin emissions by pulp and paper plants. In addition, stringent BAT standards for petroleum refining proposed in late 1979 were not implemented in the U.S. A further disadvantage of using the BAT standards is that, in some industry sectors, there are significant differences between the U.S. sector and its Canadian counterpart. However, no other approach was found to be feasible so the EPA standards were used.

U.S. EPA concluded that three major industries, the pulp and paper, steam electric power, and petroleum refining, would not incur costs of complying with BAT standards. BAT regulations for electric power and petroleum refining are no more stringent than "best practical technology" (BPT) controls for conventional pollutants.

BAT regulations for the pulp and paper industry apply only to three toxics: pentachlorophenol, trichlorophenol, and zinc. The technology basis for control of PCP and TCP is chemical substitution. A U.S. EPA survey of chemical suppliers showed that no measurable increase in production costs can be expected as a result of using biocides that do not contain chlorophenolics. In addition, affected mills can use bleaching chemical that do not contain zinc. Dioxin, currently not included in BAT pulp and paper regulations, is under study by U.S. EPA. A U.S. EPA proposed regulation on BAT regulations for dioxin is scheduled to be ready by 1993. Cost estimates for addressing dioxins and organochlorines are likely to vary widely. In plant process changes are likely to be less expensive than end of pipe treatment. A 1988 study by Bonsor, McCubbin and Sprague for the Ontario Ministry of the Environment on kraft mill effluents includes estimates of treatment costs at nine plants. However, the plants are not identified and the costs include treatment for toxic and conventional pollutants.

RAP team coordinators were asked to provide production, toxic wastewater flow, and other plant characteristics for major plants within their RAP sites.

BAT costs for industries present in the RAP study areas are outlined below. The only industry that may experience significant costs, according to U.S. EPA studies, is the organic chemical industry.

Steel

U.S. EPA estimated that the U.S. steel industry (U.S. Standard Industrial Classification (SIC) 331 not including SIC 3313) would incur capital costs of C$115.45 million and annualized (annualized capital plus operating) costs of C$36.07 million in 1990 to comply with BAT standards (using BEA cost indices and 0.85 exchange rate to translate costs quoted in EPA's study to 1989 C$).

The iron and steel industry contain many products and processes. We have estimated steel industry BAT costs as a unit cost of wastewater or of process wastewater (per 1000 m^3 of flow per year). Wastewater discharge averages 22,082 gallons per (US) ton of steel produced (or 92,131 L per m ton) (U.S Department of Commerce, Census of Manufacturers, Water Use in Manufacturing series). Process wastewater is estimated at 38 percent of total wastewater or 8,391 gallons per US ton. 1989 steel production was forecast to be 89.4 million tons (81.1 million metric tons) (U.S. Department of Commerce 1989).

Costs per 1000 m^3 of annual wastewater flow are as follows:

- Capital costs for BAT:
  C$115.45 million/7,472,000 1000 m^3 = C$15.45 per 1000 m^3

- Operating costs for BAT = ½ annualized cost
  C$36.07 million/2/7,472,000 1000 m^3 = C$2.41 per 1000 m^3

Costs per 1000 m^3 of process wastewater are as follows:

- Capital costs for BAT:

  C$115.45 million/2,839,000 1000 m^3 = C$40.66 per 1000 m^3

- Operating costs for BAT = ½ annualized cost

  C$36.07 million/2/2,839,000 1000 m^3 = C$6.35 per 1000 m^3

We recognize that this recommended method does not account for economies of scale.

Metal Moulding and Casting

The metal moulding and casting (or foundry) industry (SIC 332 ferrous casting and SIC 336 nonferrous casting) BAT costs were projected at C$4.95 million for capital and C$2.92 million for annualized costs (in 1989 C dollars) by U.S. EPA. Wastewater discharge is estimated at 4,575 gallons per US ton of foundry production and process wastewater at 1,968 gallons per ton or 43 percent of total wastewater (U.S. Department of Commerce, Census of Manufacturers, Water Use in Manufacturing series). 1989 casting shipments of 'Ton and steel and nonferrous foundries is projected to be 10.53 million metric tons (U.S. Department of Commerce 1989). Total wastewater for the foundry industries in 1989 then is estimated at 201,059 1000 m^3 and process wastewater at 86,489 1000 m^3. BAT costs per 1000 m^3 per year of total wastewater are estimated as follows:

- Capital costs for BAT:

  C$4.95 million/201,059 1000 m^3 = C$24.75 per 1000 m^3

- Operating costs for BAT = ½ annualized cost

  C$2.92 million/2/201,059 1000 m^3 = C$7.30 per 1000 m^3

BAT costs per 1000 m^3 of annual flow of process wastewater are estimated as follows:

- Capital costs for BAT:

  C$4.95 million/86,489 1000 m^3 = C$57.23 per 1000 m^3

- Operating costs for BAT = ½ annualized cost:

  C$2.92 million/ 2/86,489 1000 m^3 = C$16.88 per 1000 m^3

Metal Finishing

BAT implementation cost curves for the major categories of metal finishing operations are presented in U.S. EPA's 1983 development document. These cost curves are available in the EPA documents if the process wastewater flow of a plant is known.

Organic Chemicals

Average BAT compliance cost estimates for organic chemical producing plants or processes within RAP areas are difficult to derive. The organic chemical industry includes a large number of products and processes that depend largely on petrochemicals as feedstocks. The industry's subsectors are organic chemicals, plastics, and synthetics. EPA's toxic wastewater regulations issued in 1987 affect organic chemicals, plastics, and synthetic fibres from SIC groupings 282 and 286 (SIC 2821, 2823, 2824, 2865, and

2869).

U.S. EPA projected that capital expenditures on toxic water pollution control could reach eight to ten percent of total annual capital costs for the organic chemical industry during 1988 to 1995. Capital costs of compliance with BAT were estimated at C$437.82 million and annualized costs at C$281.99 million (in 1989 C$). EPA's BAT cost estimates are largely based on a review of treatment methodologies and plant effluents.

BAT compliance costs estimates for plants in RAP areas are estimated in terms of dollar per unit of flow of Process or total wastewater. About ten percent of wastewater from organic chemical plants is termed process wastewater it comes in contact with or results in production of products (EPA, Development Document, 1987). The rest of the wastewater is non-process wastewater, mostly from power generation and other cooling. EPA's 1987 regulations apply to process wastewater. EPA estimated that the average daily process wastewater discharge per plant is 1.31 million gallons per day for direct dischargers (Federal Register, Vol 52, p 42526). A total of 654 U.S. plants were expected to be affected by the BAT regulations for a total average daily discharge of 856.74 million of gallons per day (MOD) or 3,242.76 1000 m^3 per day or 1,183,608 1000 m^3 per year.

Production of organic chemicals in 1988 in the U.S. for SIC 2821, 2823, 2824, 2865, and 2869 was projected at 156.1 billion lbs or 70.8 billion kg (70.8 million m tons) for the five SIC codes considered by EPA (EPA 1987).

BAT costs in terms of 1000 m^3 of annual process wastewater flow are:

- Capital costs:

  C$ 437.82 million/1.183608 million 1000 m^3/yr =
  C$ 370 per 1000 m^3

- Operating costs:

  C$ 281.99 million/2/1.183608 million 1000 m^3/yr =
  C$ 119 per 1000 m^3

Inorganic Chemicals

EPA's development documents for the inorganic chemical sectors contain BAT cost estimates for model plants in these subsectors. These cost estimates can be used for plants producing these chemicals in the RAP areas.

U.S. EPA's estimate of the capital costs of compliance with BAT for the inorganic chemicals industry were estimated at C$29.56 million and annualized costs at C$28.51 million (in 1989 C$) for the following industry subcategories: chlor-alkali, chrome pigments, hydrogen cyanide, hydrogen fluoride, the titanium dioxide-sulphate process segment of the titanium dioxide subcategory, and sodium chlorate. Cost curves or equations are available for some of the subindustry categories.

Costs for the chlorine production (mercury cell process) used at the Cornwall CIL plant are based on the following model plant characteristics:

Process Wastewater Flow (1000 m^3/yr)	Tons Produced/yr	BAT Capital Cost per 1000 m^3/yr (1989 C$)	BAT Operating Cost per 1000 m^3/yr (1989 C$)
44100	21000	1.59	1.29
221550	105500	0.54	0.36
442050	210500	0.42	0.28

3. URBAN NONPOINT SOURCE POLLUTION

Control and treatment of urban stormwater discharges and combined sewage overflows are water quality problems that increase in importance with urbanization. A large percentage of the total organic and toxic pollutants entering receiving waters can be caused by sources other than point sources. A common rainfall can produce flow rates up to one hundred times dry weather flow scouring urban surfaces and discharging flows through steams, gullies, and culverts. Storm events also cause combined sanitary and storm sewers (CSO) to overflow, flushing sanitary sewage directly to receiving waters.

Information on costs of stormwater runoff control and sewage separation was gathered from Canadian and U.S. RAP teams, U.S. EPA's Nonpoint Source office, and several urban wastewater authorities in Canada and the U.S. Several standard engineering texts and cost data prepared by municipal or regional authorities also contain urban nonpoint control costs. Apogee Research previously conducted urban runoff control studies for the City of Seattle, Washington, and the Puget Sound Water Authority. The costs of urban runoff control and treatment are likely to be among the highest costs of any of the remedial actions.

Several costing options were examined. In the end, we choose a stormwater utility approach to estimating urban runoff treatment and control costs. The strength of this approach is that it offers a consistent basis for estimating costs across all sites. The weaknesses are that it may underestimate costs and may be based on water quality standards that are less stringent than those being contemplated by MOE. The stormwater utility approach is outlined below following a comparison of three ways to estimate the costs of urban nonpoint source pollution cleanup.

Engineering Approach

During the past two decades Best Management Practices (BMPs) have been developed and implemented in urban areas to control and treat stormwater. These BMPs provide both nonpoint source pollution control and effective stormwater/flood management. BMPs include structural measures such as detention and retention basins, infiltration devices, and porous asphalt paving; physical, chemical, and biological treatment; and nonstructural measures such as preservation of wetlands, system maintenance, and system optimization (integrated structural and nonstructural measures).

Cost estimates for implementing BMPs in an urban area require knowledge about the present stormwater facilities, a stormwater master plan, and/or details about storm flow, land slope and permeability, number of CSO outlets, land availability for basins, and other characteristics. Ranges of costs of implementing BMPs are available from cost curves and cost estimates published in guidebooks. Costs are expressed in terms of dollar per litre of flow or dollar per kg of phosphorus removed.

Comparative Approach

Cost estimates of implementing comprehensive stormwater and urban runoff water quality management can provide indications of cost for other cities. Examples include major studies for Boston Harbour and the Rouge River (Detroit, Michigan).

Stormwater Utility Approach

A stormwater utility relies on dedicated user fees rather than tax revenues to fund stormwater and urban runoff control and treatment. A stormwater utility is a public utility operated or regulated by the government. Like a water or wastewater utility, costs are allocated according to service received (or amount of runoff generated). Each parcel of land within the utility's jurisdiction is assessed a charge based on its runoff characteristics and size.

There is a consensus among public works officials that the utility approach is the best way to finance stormwater management (Lindsey 1988b). Utilities are a stable, secure source of funds. Many people also believe that user charges based on one's contribution to the problem are more equitable than income or property taxes.

Stormwater utilities exist in more than fifty communities or cities in the United States. They serve both small (e.g., Wooster, Ohio; 20,000 population) and large communities (e.g., Denver, Colorado; more than 1 million). These utilities generate substantial revenues ranging from US$263,000 to over US$8 million per year (1986 U.S. dollars). In a survey of 25 stormwater utilities (with 19 respondents), Lindsey (1988a, 1988b) developed several rule-of-thumb measures of the revenue generating potential of the utilities (expressed in 1986 U.S. dollars):

- Per capita utility revenues just from user charges range from US$7.33 to US$27.27 annually. This rule-of-thumb spreads all charges, including those paid by industrial and commercial properties, etc., across the entire population. No utilities actually charge on a per capita basis.

- Revenues per developed acre within the utility service area range from US$50.45 to US$122.06 annually.

- Annual charges for single family residences range from US$15 to US$52.80.

- Charges to single family residential users account for between 24 percent and 62 percent of all revenues from user fees.

Planning for a stormwater utility involves systematic consideration of a series of political, managerial, financial, and technical issues (see Lindsey 1988b; Camp Dresser & McKee 1986) including design of a master plan of BMPs, estimation of revenue requirements, identification of sources of revenue, and development of a billing system and stormwater utility ordinance.

Selected Cost Estimation Method for RAP Sites

For RAP sites for which no engineering or incomplete engineering cost estimates are available, we have selected the stormwater utility approach as the method of estimating a range of costs for control and treatment of urban runoff. The stormwater utility survey data is based on many more examples than the small number of master plans we were able to review. In addition, the stormwater utility revenue figures are derived from actual revenues based on BMP master plans and operational procedures.

In practice, the range of activities financed by stormwater utilities varies greatly (Lindsey 1988b). Some utilities fund both capital and operation and maintenance expenditures with utility revenues. Others use utility revenues only for planning and operation and maintenance and finance capital improvements by issuing general obligation bonds that are repaid by property tax revenues. For this reason, the utility fees may understate the costs of achieving certain ambient water quality standards or water uses.

The cost method for estimating urban runoff control and treatment for a RAP area is as follows:

1. Assume that a stormwater utility is in operation in the RAP area implementing a master plan of BMPs.

2. Select C$30.00 per capita per year as an estimate of the revenue collected in the RAP area. We selected a figure of C$30.00 (at the higher end of the survey data to account for understatement outlined in the previous paragraph).

3. Multiply per capita per year revenue by RAP area population to derive total annual revenue.

4. Assume that operation and maintenance costs are 50 percent of annual revenues (in general, O&M costs are half of an annualized capital plus O&M figure for public works).

5. Derive present value of capital costs by discounting 50 percent of annual revenues over a 20 year period at a discount rate of 10 percent. This assumes that capital is amortized over a 20-year period.

4. AGRICULTURAL NONPOINT SOURCE POLLUTION

Estimates of the costs of controlling agricultural nonpoint source pollution in the RAP areas is based on our review of recorded and estimated costs and cost effectiveness of implementing nonpoint source control programs in watersheds of different sizes, agricultural base, and runoff volumes in the Great Lakes region of both Canada and the United States.

The Ontario Ministries of the Environment and Agriculture and Food and Agriculture Canada are active in agricultural NPS demonstration and study projects. These projects now under way, such as "SWEEP" and 'Tillage 2000," will generate BMP cost and cost effectiveness numbers over the next few years. One completed study, the Ontario Rural Beaches Study (MOE) estimated the cost of feedlot, dairy operation, and sceptic tank cleanup. Another study for the RAP team at Bay of Quinte estimated the costs of conservation tillage.

In the United States, the U.S. EPA Great Lakes Program, Nonpoint Source Pollution, and Water Economics offices; the U.S. Department of Agriculture Soil Conservation Service and Economic Research Service; and RAP team coordinators in Wisconsin, Michigan, and New York are among those we have contacted for information about the cost of implementing agricultural nonpoint source pollution programs. U.S. federal and state agencies have conducted agricultural NPS BMP programs for over a decade. U.S. EPA recently published a study evaluating the cost effectiveness of agricultural best management practices and sewage treatment plants in controlling phosphorus in the Great Lakes region.

For purposes of estimating cropland BMP costs in RAP areas, we have selected the results of a linear programming simulation model based on demonstration project data in Honey Creek, Ohio.[1] BMP cost or cost effectiveness data from most other studies is BMP specific and does not provide overall costs for a mix of BMPs. The Honey Creek case study simulates optimal combinations of BMPs and crop selection and yields. The model yields cost effectiveness data and ranges of reliability for reducing phosphorus and pesticides and herbicides. We selected the case of 50 percent reduction in phosphorus loadings with a 50 percent reliability and pesticide use restrictions sufficient to meet recommended maximum contaminations levels with a 50 percent reliability. These parameters generate a cost effectiveness of US$7.17 per lb per year (1985 U.S. dollars) or 1989 C$20.08

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1 DPRA Inc. 1989. An evaluation of the Cost Effectiveness of Agricultural Best Management Practices and Publicly Owned Treatment Works in Controlling Phosphorus Pollution in the Great Lakes Basin. Report to the US EPA.

per kg per year. Cost-effectiveness is the annualized cost to the farmer.

For RAP watersheds for which the phosphorus loadings from cropland are known, the cost-effectiveness is multiplied by 50 percent of the phosphorus loading to derive the watershed cost to the farmers of implementing cropland BMPs. One half of the annualized costs is assumed to be operation and maintenance costs. The other half is assumed to be capital costs which are discounted to the present using a 10 percent discount rate over a 20 year capital recovery period.

In cases where the phosphorus loadings from cropland are not known, the number of hectares is multiplied by 50 *percent* of an average annual phosphorus runoff of 5.88 kg per hectare (5.25 lbs/acre/yr - from EPA 1989)[2] and then multiplied by the cost-effectiveness figure.

The cost range estimates for a feedlot runoff control system are C$11,431 to C$20,232 for capital costs and C$508 to C$1,016 for annual operation and maintenance (1989 C$) for a 500 head feedlot operation. These figures, a composite derived from several U.S. case studies summarized by EPA (1989), are used as the average cost to the farmer of implementing feedlot BMPs. Per head costs are then C$22.86 to C$40.46 for capital costs and C$1.02 to C$2.04 for O&M costs.

Government costs of providing incentives and technical assistance to farmers to implement BMPs are not estimated. Costs to government agencies vary widely depending upon the percentage of BMP cost-sharing funded by the government agency.

5. CONTAMINATED SEDIMENT REMEDIATION

Capital cost estimates for dredging harbour sediments and disposal of the sediments in confined nearby land disposal sites with clay or other impermeable liners are reported to be in the range of C$50 to C$70 per m^3 of sediment dredged (information gathered by the U.S. Army Corps of Engineers). The actual dredging cost ranges from C$5 to C$10 per m^3. The balance of the cost is for site acquisition and preparation and transport, disposal, and treatment of the sediments. The U.S. National Academy of Sciences will

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2 ibid

soon publish a study summarizing toxic sediment dredging and disposal methods and costs.

The cost of capping toxic sediments in place is the cost of dredging, transporting, and placing material over the area. Capital costs range from C$10 to C$15 per m^5 of dredged material dredged, transported, and placed on the toxic area. Capping costs are also based on cost estimates provided by the U.S. Army Corps of Engineers. Capping has been undertaken at several sites in Japan and was considered for the New Bedford harbour, Massachusetts, Superfund site.

6. TOXIC WASTE DISPOSAL SITE CLEANUP

Waste disposal site cleanup cost estimates vary widely.

Canadian studies have produced widely differing estimates of site remediation and site recovery costs. Limited experience to date has shown that costs can be in the tens of millions of dollars.

Costs for ongoing and future hazardous waste and "Superfund" sites have been estimated by various U.S. government agencies. These costs were summarized by the U.S. Congress' Office of Technology Assessment (OTA) (1985). In the early 1980s, U.S. EPA estimated that the average federal cleanup cost per site (capital cost) would be about US$7.5 million and average operation and maintenance costs US$400,000 (OTA 1985).A more recent U.S. EPAprojection following new cleanup standards initiated in 1986 is US$30 to US$40 million per site (National Council on Public Works Improvement 1987). If long term groundwater cleanup costs are included, costs may be as high as US$300 million to US$600 million per site.

For this study, the limited knowledge available about the toxic waste sites led to the decision to estimate only the cost of removing the waste site material so that it could no longer continue to contaminate the area of concern. A cost estimate range of $100 - $200/tonne was used. Note that this cost does not include the cost of treating this waste: just disposing of it elsewhere.

Appendix C

Demographic Data for RAP Sites
Target Areas1986, or 1988 where available
(thousands)

Site	Total Population	Population 12 Years and Over*	Number of private Households
THUNDER BAY			
Thunder Bay CMA	122.4	102.6	43.7
NIPIGON BAY			
Nipigon	2.4	2.0	0.8
Red Rock	1.5	1.3	0.5
TOTAL	3.9	3.3	1.3
JACKFISH BAY			
Terrace Bay	2.7	2.8	1.1
Jackfish	n/a	n/a	n/a
PENINSULA HARBOUR			
Marathon	3.4	2.8	1.1
ST. MARY'S RIVER			
Sault Ste. Marie	84.6	69.9	29.5
ST. CLAIR RIVER			
Sarnia	49.9	40.5	19.4
Point Edward	2.3	1.9	0.9
Moore township	10.1	8.4	3.6
Sombra	4.2	3.6	1.5
Wallaceburg	11.4	9.5	4.1
Walpole Is. Indian Reserve	1.4	1.0	0.4
TOTAL	78.4	64.9	29.9

Site	Total Population	Population 12 Years and Over (thousands)	Number of Private Households
DETROIT RIVER			
Windsor	193.1	163.2	72.7
Amherstburg/La Salle	8.4	7.1	2.8
TOTAL	201.5	170.3	75.5
SPANISH RIVER			
Espanola	5.5	4.6	1.9
Webbwood	0.6	0.5	0.2
Massey	1.3	1.1	0.4
Spanish River Municipality	1.6	1.3	0.7
Spanish R. Indian Reserve	0.7	0.6	0.2
TOTAL	9.7	8.1	3.4
SEVERN SOUND			
Midland CA (incl. Penetang)	36.4	29.4	12.4
COLLINGWOOD HARBOUR			
Collingwood	12.7	10.6	4.5
WHEATLEY HARBOUR			
Wheatley	1.6	1.4	0.6
NIAGARA RIVER (includes Welland River)			
Niagara Falls	72.1	61.0	26.1
Niagara-on-the-Lake	12.5	10.8	4.4
Fort Erie	23.3	19.6	8.7
Welland	45.1	38.1	16.5
Thorold	16.1	13.6	5.6
TOTAL	169.1	143.1	61.3
HAMILTON HARBOUR			
Regional Municipality of Hamilton-Wentworth	428.2	360.8	161.5
Burlington	116.7	98.0	40.1
TOTAL	544.9	458.8	201.6
TORONTO HARBOUR			
Metropolitan Toronto	2234.6	1885.3	852.2

Population	Total	Population 12 Years and Over* (thousands)	Number of Private Households
PORT HOPE			
Port Hope	10.7	8.9	3.8
BAY OF QUINTE			
Belleville CA (incl. Trenton)	87.5	73.5	31.7
Deseronto	1.9	1.6	0.7
Napanee	4.8	4.0	2.0
Picton	4.2	3.5	1.7
TOTAL	98.4	82.6	36.1
ST. LAWRENCE RIVER			
Cornwall	53.0	44.2	18.9
Lancaster Township	4.0	3.3	1.8
Charlottesburg Township	6.8	5.7	2.7
Akwesasne Indian Reserve	0.7	0.6	0.2
TOTAL	64.5	53.8	23.6
TOTAL - 17 RAP SITES	3679.5		1381.6
ONTARIO			3376.8

Sources:

Statistics Canada 1986 Census.
Financial Post Information Services, Canadian Markets, 1988/89.
Ministry of Municipal Affairs, Municipal Directory 1988.

* The population age group of 12 years and over has been estimated through interpolating data on the population of the 10-15 age group according to the 1986 Census.

Appendix D

Framework for Assessment Of Economic Consequences

Introduction

In this section we discuss two distinct approaches to measuring the economic effects resulting from any given investment.

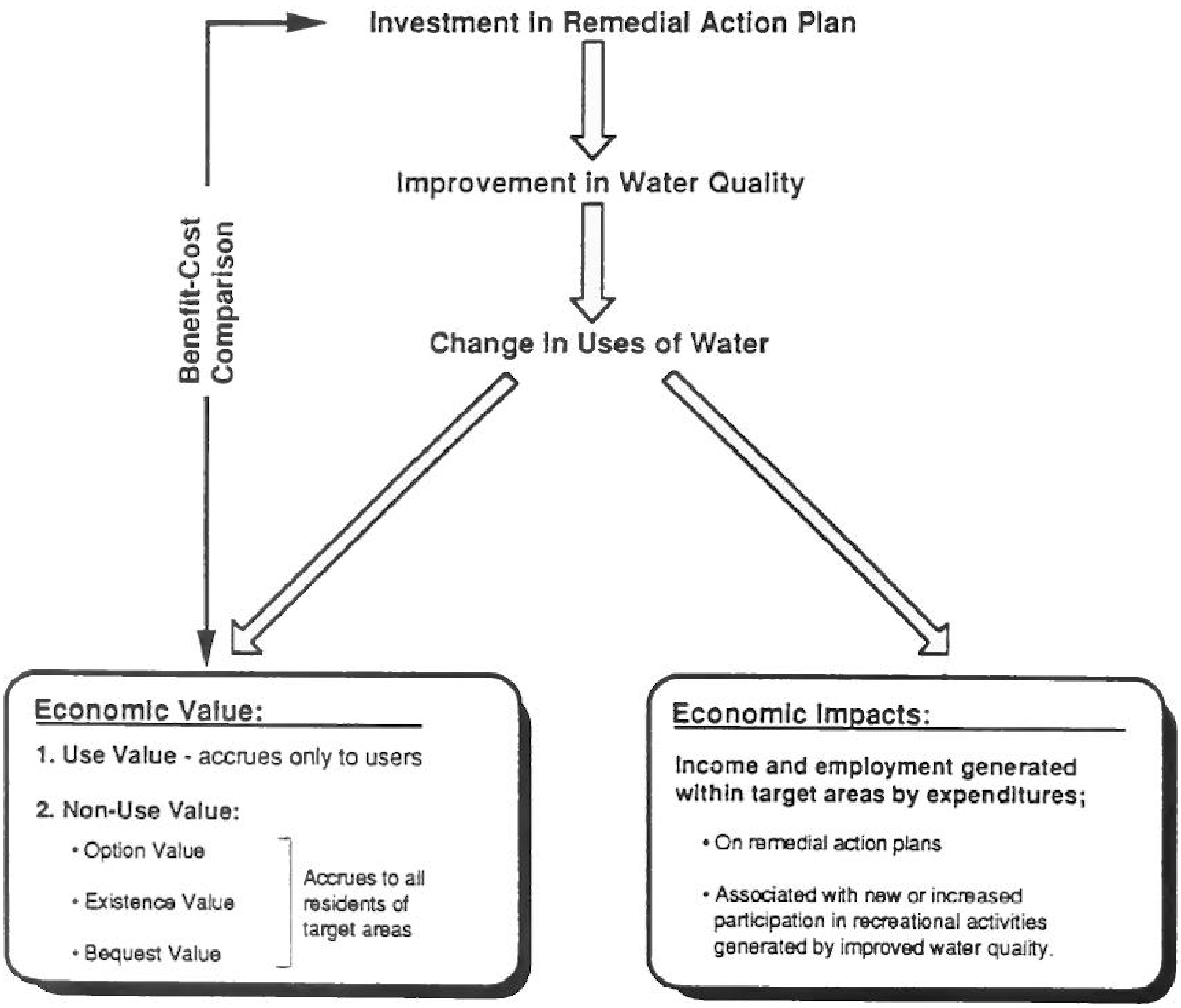
One approach used to measure the economic effects of increased recreational activity is to measure the "welfare" or "economic value" benefits which accrue to the participants from engaging in, or knowing that they could engage in, the activity or activities. The second approach involves measuring the "economic impacts" arising from expenditures made in implementing the Remedial Action Plans (RAP'S) and in connection with the increased recreational activity which occurs as a result of their implementation. (The two approaches are described schematically in Exhibit D-1, overleaf.)

In the case of both economic impacts and economic value analysis, it is necessary to distinguish the geographical area for which effects are to be calculated. In the case of economic value analysis, only the increased welfare accruing to residents of the target area is relevant. In the case of economic impact analysis, expenditures which give rise to income and employment within the target area are relevant; those which give rise to income and employment outside the area are not.

Analysis of Economic Value

Any given investment gives rise to a change in the selection and/or price of goods and services which are available to, or externalities which are imposed on, consumers. In the case of investment in pollution control measures at the RAP sites, the "goods" created are cleaner water and any activities which are made possible or are enhanced by the change in water conditions. The economic value of these goods is the difference between the full value of the good or activity (the maximum price or amount of expenditures that individuals would pay for the good or activity) and the price or expenditures actually incurred by these individuals in "consuming" the good or participating in the activity.

Exhibit D-1: Framework For Assessing Economic Effects.



The concept of economic value is illustrated in Exhibit D-2, <u>overleaf.</u>

The Exhibit shows the situation for a traditional market-traded good. The demand curve (ABC) is a schedule which shows the relationship between various prices of the commodity and the corresponding quantities of the commodity desired at that price. A demand curve can in principle be developed for both individuals and the total market. (The market demand curve is derived by aggregating individual demand curves.)

For traditional goods, the demand curve, if plotted, will slope downward to the right such as the straight-line demand curve pictured in Exhibit D-2.

In fact, demand curves are generally curved and may be relatively flat or steep, reflecting demand characteristics relevant to the specific commodity. The downward slope merely indicates that as the price per unit of the good increases, the quantity demanded decreases. Put another way, the "marginal value" of additional units of a commodity are decreasing; the consumer is not willing to pay as high a price per unit for "Q" units than he is for a lesser quantity (say, "Q"' units) of the commodity.

The supply curve shown in Exhibit D-2 slopes upward to the right, indicating that as the price of the good increases, the quantity produced also increases. The point of intersection between the supply and demand curves indicates the quantity at which the marginal cost of production (for the producer) equals the marginal value in use (for the consumer). At this point of equilibrium, the price for the commodity is determined as "P".

The total amount which consumers must pay for "Q" units of the commodity is indicated by the area POQB. However, collectively individuals would be willing to pay a price higher than "P" for fewer than "Q" units. Thus, individuals' total willingness to pay is represented by the area AOQB. The difference between these two quantities - that is, the value of the area APB - is called "consumer surplus" or "net willingness to pay" and represents the "economic value" of the good in question.[1] It is this measurement of value which is consistent with the concept of "benefit" as used in benefit-cost analysis.

In practice, of course, demand curves for particular commodities are not directly observable. They can, however, be approximated with reference to the way in which the quantity demanded changes in response to changes in its price.

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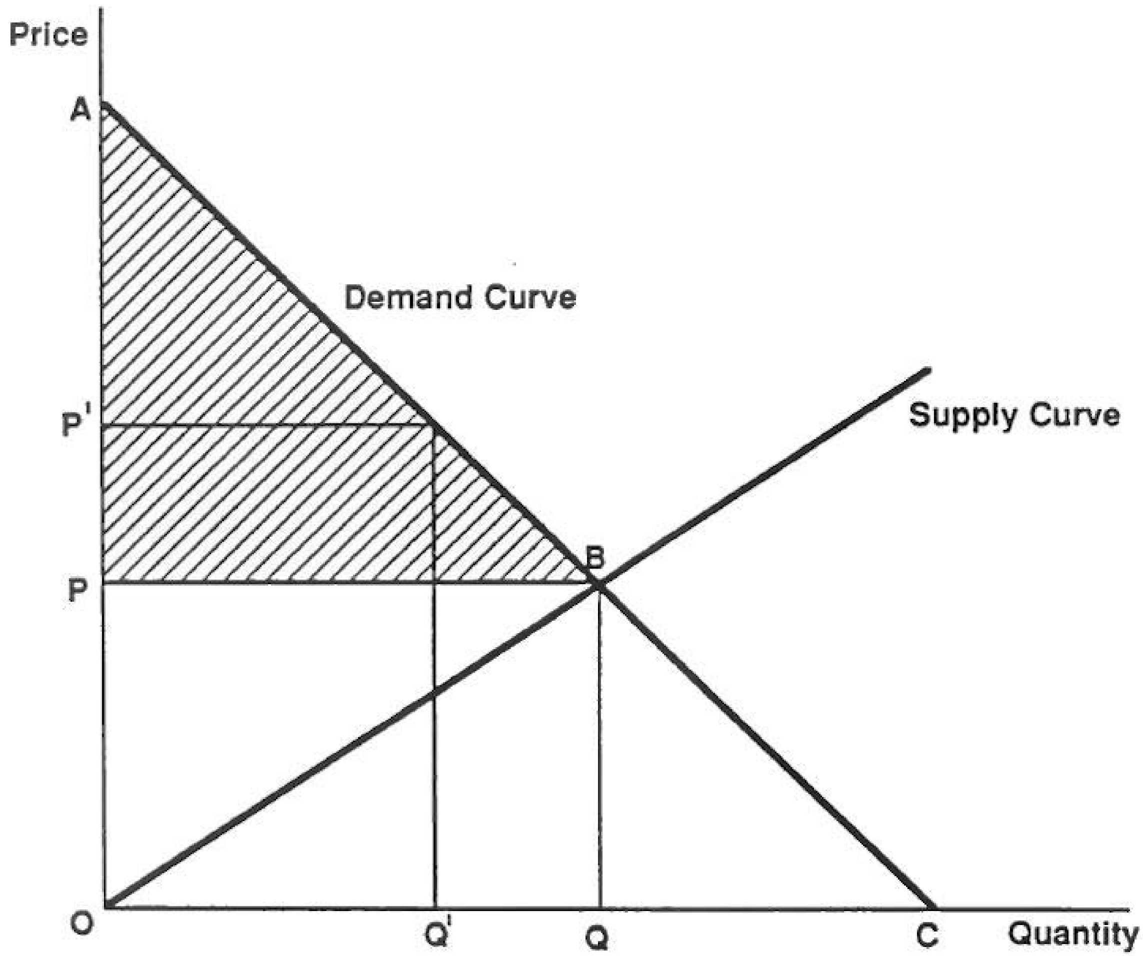
1 Conversely, for an upward sloping supply curve such as that shown in Exhibit D-2, producers would be willing to accept a lower price for selling fewer than "Q" units of the commodity. Thus, "producer surplus" or "economic rent" is represented by the area POB.

Exhibit D - 2: The Concept Of Economic Value - Consumer Surplus.



This is usually relatively easy to determine based on past experience or on observed consumer behaviour relative to a similar good. Once known, the demand curve for the commodity can be determined. Total consumer surplus, or the change in consumer surplus, can then be calculated geometrically.

Economic Impact Analysis

Economic impact analysis makes no reference to the welfare, or economic value, which is generated by consumption of goods and services, but is essentially an analysis of the expenditures made in connection with given activities, and of the impacts in terms of income and employment accruing within the target area as a result of these expenditures. The process by which these increases occur (using sportfishing as an example) is as follows.

Expenditures are made on goods and services related to recreational fishing. Increased demand for these goods and services results in an increase in their production and, hence, in the amount of inputs used in their production. Some of these "inputs" are labour, an increase in the use of labour translates into an increase in employment and income for the workers affected. Other inputs used in the production of the recreational goods and services are materials; they, in turn, require increased production and result in additional employment and income to workers. Eventually, all of the expenditures made in connection with the recreational activity - both directly and indirectly - translate into income either in the form of profits, payments to labour, or taxes. Finally, recipients of the income spend part or all of the proceeds and these expenditures reverberate through the economy with further employment *and* income effects.

Not all of the employment and income effects are retained within the targeted geographical area. Some of the expenditures will be made on labour and on goods and services produced partially or wholly outside the area. The larger and more diverse the area in question, the smaller these "leakages" will be.

The amount of employment and income retained by the target area represents the economic impact of the initial investment. These effects are generally calculated by the way of "multipliers" which relate the final increases in employment and income to the initial direct expenditures. For example, if the income multiplier from sportfishing were 1.2, final total income accruing to residents of the target area would be equal to 1.2 times the initial expenditures made on the recreational activity. Employment multipliers, estimating the number of jobs or person-years of employment created per unit of initial expenditure, can be used to calculate the final employment effects within the target area.

Generally, the methodology for economic impact analysis is relatively straightforward. However, some qualifications may be in order regarding the calculations which result. In particular, economic impacts are not always incremental. If, in the absence of the expenditure on sportfishing, an equal amount of expenditure would have been made on other goods or activities giving rise to similar income and employment effects in the target area, the net economic impact is zero or close to zero. For example, assume that the alternative to fishing is going to a local bowling alley. With the improvement in water quality, the hypothetical resident stops bowling and goes fishing instead. Both activities generate expenditures within the target area and the net economic impact of the fishing expenditures may be zero or even negative. On the other hand, if the alternative to fishing is staying at home or fishing in the Muskokas, diversion from these activities to fishing at the RAP site(s) results in positive net impacts within the target area. However, data are seldom available on substitute activities and thus, economic impacts are generally all assumed to be incremental.

Appendix E

Description of Benefit-Cost Analysis

Introduction

This section explains the theory of benefit-cost analysis with reference to investment in pollution control. It also describes types of benefits associated with improvements in environmental conditions and methods for valuing these benefits.

What Is Benefit-Cost Analysis?

Benefit-cost analysis is essentially an extension of private profitability analysis. However, instead of assessing only the monetary impacts of an investment project on the private investor, benefit-cost analysis seeks to evaluate all relevant social costs and benefits within the target area. The benefits in benefit-cost analysis correspond to the concept of economic value discussed in Appendix D. There may be disbenefits as well - anticipated or unintended - associated with the investment under consideration.

Benefit-cost analysis is intended to maximize "allocative efficiency" - that is, to maximize the net benefits to society resulting from the use of its resources as inputs to the production and consumption of goods and services. The conceptual framework for achieving this is described in the following paragraphs and in Exhibit E-1, overleaf.

As shown in Exhibit E-1, a control measure results in a change in water quality as measured by a reduction in certain pollutants. An "abatement cost function" relates the reduction in specific pollutants to the cost of the alternative control measures. It represents, in functional form, the minimum cost for achieving a given level of abatement of a specific pollutant.

In principle, the abatement cost function is developed by considering all possible abatement strategies and selecting only those which give the most cost-effective approach to any given level of abatement. This approach is complicated by the fact that the cost of achieving a given level of abatement of any one pollutant depends on the levels of abatement which have already been selected for other pollutants. However, abatement cost functions can readily be developed for reduction in individual pollutant loadings from each source, and in many cases, can be developed for the group of pollutants which are critical to a particular restored use of the sites. For any selected level of abatement, a cost is incurred which, appropriately valued, enters the benefit-cost analysis. This is shown on the left-hand side of Exhibit E-1.

The change in water quality which arises in connection with the abatement measure affects the type and amount of use of the water. For example, reductions in phosphorous may result in increases in preferred fish species and, therefore, in fishing activity. Measures which reduce coliform counts may permit swimming. Other things being equal, the abatement expenditure, determining the level of abatement, influences the type and level of water usage. This usage change, once properly valued within the benefit-cost framework, is a net benefit associated with the abatement measure, or remedial action plan.

In effect, we can repeat this analysis over the various types of pollutants with their associated abatement cost functions and aggregate the results. This provides an estimated total net benefit of a RAP.

Perhaps the net social benefit can be increased by adjusting the aggregate expenditure on abatement or by changing the mix of the various pollutants targeted and the associated abatement strategies. Economists have identified the conditions under which maximization of social benefits would occur; in simplified form, they are maximized at the point at which the marginal costs of additional abatement would equal the social valuation of marginal increases in usage and other benefits associated with the same levels of abatement.

It should be emphasized that the above description pertains to the ideal conceptual framework. Due to limited data and resources, it has not been possible to adhere to this "ideal" framework at every step in this study. Instead, the framework is outlined and quantified where possible; although the analysis is undertaken with the "ideal" conceptual framework in mind, the process is not as exhaustive as described above. As such, this study constitutes a benefit-cost "framework" or "assessment" rather than a benefit-cost analysis per se.

Appropriate Valuation of Costs and Benefits

If the benefit-cost assessment is to provide a guide to optimal resource allocation, it is necessary that all costs and benefits be valued at their opportunity costs - that is, the value of the foregone opportunities associated with choosing one activity over another. If market prices are used to calculate costs and benefits, it is necessary that they reflect the true social value of the goods or activities concerned. Future costs and benefits must be discounted at the "social" rate of discount In the case of natural resources such as water, the opportunity cost includes the impacts or consequences of current use on the availability and quality of future supplies.

In many cases, the valuation of costs and benefits can be made in a straightforward way by reference to the market price of similar goods and services. In the absence of market imperfections, these prices represent the "opportunity costs" of the goods and services. Use of market prices is appropriate when valuing the cost of pollution abatement measures. These estimates include the cost of all labour and materials used in conjunction with the capital construction, operation and maintenance of the control measures.

Valuation of the benefits is not as straightforward as the valuation of costs. The "good" which is produced by pollution abatement at the RAP sites is cleaner water. Since water is not traded on a market, there is no price attached to it, and no way of determining by reference to its market what the increase in value of water at the sites might be as a, result of making it cleaner. However, it is clear that there is a "disbenefit" attached to having water of unacceptable quality at the sites and, conversely, a value attached to making it cleaner.

A number of studies have been done in the United States initially, and in Canada more recently, which attempt to evaluate changes in water quality including the value of associated recreational activities. Collectively, these studies have identified four types of economic value benefits associated with changes in water quality:

- **Use Value** - The value attached to actually using the cleaner water—for instance, for a recreational activity such as sportfishing. In this case, use value would accrue both to all "new" anglers at the sites, and also to those who fished at the sites before the improvement in water quality but who gain more satisfaction from the fishing experience now because of the improved conditions.

- **Option Value -** An "insurance" value which individuals, whether or not they use the water directly, attach to preserving or creating the option to use it at some point in the future. Attempts to actually measure option value have been fairly recent but, because they suggest that option values may be quite large even for resources which are not unique, there is considerable interest in this concept.

- **Existence Value - The value that individuals place on** simply knowing that water is cleaner and that recreational opportunities exist which formerly did not or which formerly were not enjoyable to the same extent, even if the individuals do not expect ever to use the water directly.

- **Bequest Value** - The value individuals place on being able to pass on to future generations better environmental conditions.

The last three values are termed "non-use" values because they do not relate to current use of the water resource. Alternatively, they may be called "intrinsic", "preservation", or "amenity" values.

Application of the Theory of Consumer Surplus to Cleaner Water

Reducing pollution at the RAP sites gives rise to use and non-use values. Simply knowing that the water is of acceptable quality confers a benefit to residents of the sites in the form of existence and bequest values. Creation of particular water conditions makes possible certain activities which were not formerly possible, or were not enjoyable to the same extent, thereby generating use and option values. However, these values may not be quantified by reference to market prices. Neither cleaner water nor recreational activities are traded on the market and even if they were, their prices would be useful only in estimating use values. However, the concept of consumer surplus is still applicable. It must simply be measured by methods which do not make reference to market prices. The remainder of this discussion, therefore, uses recreational fishing as an example of how to quantify the benefits associated with a non-market traded good.

Hypothetical supply and demand curves for recreational fishing are shown in Exhibit E-2. There is no explicit price attached to recreational fishing which accurately represents its social value; however, there is an amount which individuals are willing to pay in order to pursue the activity. This is represented by the vertical axis. As in the case of a traditional market good, the willingness to pay (WTP) decreases as the level of the activity increases, resulting in a downward sloping demand curve.

The shape of the supply curve is not clear. It has been suggested by a number of authors that the consumers and producers of the activity are the same people. The consumer undertakes recreational fishing and, therefore, supplies it to himself. The supply curve may be perfectly elastic - that is, flat - or it may slope upward to the right.

Assume that control measures are implemented which have the effect of improving fishing conditions. The result is that the amount of fishing undertaken is greater for any given "price" such that the demand curve shifts from Do to D'. In this case, assuming the supply curve is fixed at So, consumer surplus is increased by an amount equal to the area.

Alternatively, the improvement in water quality can be viewed as reducing the expenditures which anglers must make in order to obtain a given quality of fishing. For example, anglers who formerly fished in the Muskokas may now find the same quality of fishing at one of the sites and at much lower travelling cost. Thus, the supply curve has, in effect, shifted down, say, to S". In this case, assuming the demand curve is fixed at Do, the change in consumer surplus is represented by the area PHJB.

The problem still remains, however, of how to quantify the consumer surplus. This is discussed in the following section.

Methods of Quantifying Consumer Surplus

There are a number of methods which can be used in quantifying the economic value or consumer surplus associated with recreational activities resulting from improvements in water quality. (These methods are described in detail in a number of sources listed in Appendix F.) The two approaches which have been used most often in recent studies are the "contingency valuation method", and the "travel cost method". A brief discussion of each of these methods and the associated difficulties and limitations follows.

The essence of the contingency valuation method is a survey of individuals to determine the amounts they would be willing to pay, over and above existing expenditures, for a given improvement in water quality (generally stated as expenditures per year) or for a particular recreational activity which this water quality improvement makes possible or enhances (generally stated on a per day basis). Conversely, the individuals might be asked to estimate the minimum amount of money they would be willing to accept to forgo such an improvement or recreational activity. Theoretically, these two measures are not equivalent but should yield similar results. The survey approach may also be used to determine amounts individuals would be willing to pay for avoiding a deterioration in the level of water quality.

There are a number of criticisms of this approach. First, there may in fact be substantial variation in WTP estimates and estimates of compensation required. The difference may be attributable to the fact that WTP estimates are theoretically limited by budget constraints whereas those for compensation required are not On the other hand, if the respondent views the situation being described as purely hypothetical, he may indicate a WTP which is far beyond his budget constraint. In addition, responses may vary according to the ways in which the water quality improvements (or deterioration) are described, the proposed payment vehicles, and the approach used to generate estimates of WTP. The latter may include an open-ended question, a bidding situation with the starting points suggested by the interviewer, or choice by the respondent of one of a selection of values suggested by the interviewer. Particular difficulties arise when trying to explain to respondents the difference between values which are to be estimated for use of the resource or participation in the recreational activity, and those which are to be assigned to preserving future use of the resource (option or bequest values) or for simply knowing that the resource is at a higher quality than it might otherwise have been (existence value).

The travel cost method is based on the theory that users of a recreational site pay a "price" for using that site which includes the costs of travel and time incurred in getting to the site. By observing the behaviour of users of the site from different locations, it is possible to generate a "demand curve" for the site"s services. It is then possible to derive a value for consumer surplus - the value of the area under the demand curve.

One problem associated with this approach is that it may not always be possible to isolate recreational values if trips are made for purposes which are in addition to recreation. Also, there are substantial difficulties inherent in valuing time. In addition, the travel cost approach allows estimates of use value only and provides no indication of option, existence or bequest values.

Notwithstanding the limitations of these two approaches, they are useful in providing indications of the economic value of activities or conditions for which there are no market prices.

Ways of Comparing Costs and Benefits

There are a number of ways to compare streams of costs and benefits associated with a given investment program. One is to discount them using a social discount rate which reflects society"s marginal time preference and includes some assessment of the probability (a risk) of the projected benefits and costs. Discounting results in a net present value for each stream. Another approach, and the one used in this study, is to calculate benefits and costs in a typical year following the investment, converted into constant (1989) dollars. Both the annual values and the varying streams described above have the same net present value.

Appendix F

Description Of Consumer Surplus Estimates For Swimming And Recreational Fishing

Swimming

Exhibit F-1, overleaf, lists the estimates of consumer surplus associated with swimming which were used as the basis for estimating use value from new swimming activity at the RAP sites. This appendix describes the studies from which these estimates were drawn. The studies noted in this Exhibit, and in Exhibit F-2, are referenced more fully in Appendix I. (Reference numbers noted in this Appendix refer to sources listed in Appendix I.) Due to time and budget limitations, the review of these studies did not include an in-depth, critical evaluation of the methods used nor, therefore, of the results obtained. The estimates listed in Exhibit F-1 reflect average, as opposed to marginal values of a swimming day. They have been converted into 1989 dollars based on the Consumer Price Index for Canada.

The fast estimate—of $4-8 per swimming occasion—is derived from a study done for the Ontario Ministry of the Environment, entitled "Beach Use and Environmental Quality in Ontario" (Reference #I-42). This study derives the value of home-based and non-home-based swimming occasions, based on a formula using the travel cost method. The resulting consumer surplus estimates depend on a number of factors included in the formula, such as average cost per vehicle-kilometre, a representative value of time, number of people per vehicle, average speed, and average length of trip. In deriving the range of $4-8 per swimming occasion, we assumed that the values for the first three factors were the same as those specified in the "Beach Use" study—that is, 16g per vehicle-kilometre, a value of time of $5.54 per hour, and an average of 2.9 people per vehicle. Average speed was assumed to be 40 kph, as opposed to the speed used in the "Beach Use" study of 75 kph. Assuming an average round-trip time of one-half hour, the resulting consumer surplus estimate is $4 per swimming occasion. Assuming a round-trip time of one hour, the consumer surplus is doubled to $8 per swimming occasion.

The second estimate in Exhibit F-1—of $6 per swimming occasion—is derived from another study done for the Ontario Ministry of the Environment, also in May, 1987 (Reference #I-45). This study estimates consumer surplus for recreational fishing, based on a review of the literature, and assumes that the average consumer surplus for swimming will be less than that for fishing. The estimate used for swimming is $5 per swimming occasion, in 1985 dollars. This translates into $6 per swimming occasion in 1989 dollars.

(A third study done for MOE, entitled "Beach User Benefits Study—Statistical Analysis File Report." (Reference #I-47) was, at the time of writing this report, still in draft form. Thus, its results are not reported in Exhibit F - 1 .)

Based on the two studies noted in Exhibit F-1, it was assumed that a value of $6 per swimming occasion was representative of the use value associated with swimming at the RAP sites. The use value results are reported in Section 5.3.

Sportfishing

Exhibit F-2 lists the estimates of consumer surplus associated with sportfishing which were used as the basis for estimating use value from recreational fishing at the RAP sites. These results are reported in Section 5.3. It was assumed, in that section, that the estimates reported in Exhibit F-2 are representative of the consumer surplus associated with "edible" sportfishing. The literature does not differentiate between "edible" sportfishing and fishing for which consumption restrictions might apply. However, many of the studies listed in Exhibit F-2 were done several years ago, at a time and in geographical locations where edibility of the catch, or the lack of it, was likely not a major issue. Thus, it seems reasonable to assume that the estimates in Exhibit F-2 apply to edible sportfishing. Again, as in the case of the swimming studies, our review of the studies represented in Exhibit F-2 did not include an in-depth critical evaluation of the methods used nor of the results obtained. The estimates have been converted into 1989 Canadian dollars based on the CPI for Canada, and for U.S. dollar estimates, on the annual average of noon exchange rates.

The first estimate of consumer surplus, of $12 per fishing day, is taken from a study for the Ontario Ministry of the Environment by The DPA Group Inc. in May 1987 (Reference #I-45). The estimate was derived on the basis of a literature review and reflects the average use value per angler day accruing to local fishermen at six Ontario lakes—four in the Muskoka/Haliburton Region, and two just north of Lake Ontario. The purpose of the study was to measure the increase in total consumer surplus which would accrue from a 25% reduction in phosphorous at all six lakes. The increase in consumer surplus was assumed to result from two factors: an increase in the number of fishing days and an increase in the consumer surplus per fishing day, as a result of improved fishing conditions. Equations relate the reduction in phosphorous to a change, in percentage terms, in the morphoedaphic index which in turn causes a reduction in the yield of all fish species but an increase in the proportion of preferred species to total yield. The combined result is an increase in catch per unit effort of preferred species—the factor which causes an increase in fishing days and in consumer surplus per day.

The estimates of consumer surplus for salmon fishing at various locations in B.C. are taken from the DPA report. They were derived from a 1984 study of willingness-to-pay (WTP) for a days fishing at the sites listed based on the contingent valuation method. It is not clear whether the values listed reflect WTP for a change in water or fishing quality nor, if this is the case, the degree of direction of change being valued. Two other estimates in the Exhibit—for fishing in the Adirondacks and at Snake River, Idaho—are also quoted from the DPA report. They were derived using the travel cost method and, therefore, likely reflect the use value of a day of fishing under current conditions at the two locations.

The consumer surplus estimate for recreational fishing in Alberta was derived from a study by Adamowicz and Phillips (Reference #I-1). This study involved a survey of 272 Alberta resident anglers in the 1975-76 season to determine the different values obtained using three methodologies: the direct (or contingent valuation) approach, the travel cost method, and the hedonic price or household production function approach. The estimate quoted in the Exhibit reflects the average amount respondents would be willing to pay to fish for one day (using the contingent valuation method). The results using the travel cost approach were considerably lower at approximately $8 per fishing day. The WTP estimate—of $34 per angler day— is, however, substantially lower than the average compensation which respondents would require in order to give up fishing for one day.

Victor and Burrell estimated average consumer surplus per angler day of approximately $25 (in 1989 dollars) in their 1983 study of 232 lakes in the Haliburton/Muskoka Region (Reference #I-65). The study used the Talhelm approach (a variation of the travel cost method) to estimate the potential loss in economic value from fishing due to acid rain. The different types of fishing available at the 232 lakes were grouped into "products" defined in terms of lake area and morphoedaphic index (MEI). The MEI was used as a proxy for catch per unit of effort. Demand equations were then derived for each fishing product based on the travel cost method. Supply curves were assumed to be perfectly elastic and were derived on the basis of the minimum "price" (the cost of travel and time) which anglers at each origin had to "pay" in order to obtain each fishing product. Using these demand and supply curves, consumer surplus was estimated for nine of the fishing products across all 232 lakes. The result was a range of between $9 and $193 per angler day (in 1989 dollars) depending on the fishing "product" being valued. The weighted average of the consumer surplus estimates is $25 per fishing day, as reported in the Exhibit.

The next estimate—of $6 per fishing day—is derived from a study done for the Ontario

Ministry of Natural Resources by Hough, Stansbury and Michalski Ltd. in 1982 (Reference #I-39). The estimate reflects the value per angler day for non-Indian residents for recreational fishing in Lake of the Woods and is based on a survey, undertaken in 1980, in order to determine the economic and social impacts of alternative management strategies for the Lake.

The next five values were derived from studies by Vaughan and Russell. The first showed "reasonable" low, medium, and high estimates of consumer surplus associated with sportfishing; these estimates were referenced in the 1983 study by Victor and Burrell (Reference #I-45). The purpose of the second study (Reference #I-61) was to determine the average WTP for a day of recreational fishing for different types of fish species. The study used the travel cost approach based on data from a mail survey of fee-fishing sites in the U.S. in 1979. Each site was designated to be one of three types of fisheries, including: coldwater game fish, roughfish angling and warmwater gamefish/panfish. In the end, estimates were possible for only two of these classes—coldwater gamefish (trout), and roughfish (catfish). Different estimates of consumer surplus were derived including and excluding the opportunity cost of travel time. The results reported in the Exhibit, of $36 for trout fishing and $23 for catfish fishing per angler day, include the cost of travel time valued at the wage rate.

The estimate for the Bow River, for residents and non-residents, were derived from a study for the Alberta government (Reference #I-2). The study was completed in October, 1987 and assessed the value of all recreational activities on the Bow River. Based on a survey of recreationists, it was estimated that consumer surplus attributable to all water-based recreation on the Bow River during the study was in the order of $6 per fishing-day (in 1989 dollars) for residents, and $22 for non-residents. Although this includes all types of water-based recreation, the majority of the user-days accounted for in the study, were sportfishing, (at 78% of the total).

The final estimate—of $46—was derived from a study by Kealy and Bishop reporting the results of a mail survey of anglers on Lake Michigan (Reference #I-26). The resulting estimate of consumer surplus includes time spent at the recreation site, as well as time spent travelling. (The usual approach in most travel cost studies is to include only time spent travelling.)

EXHIBIT F-1: Estimates Of Consumer Surplus Per Swimming Occasion. (in 1989 Canadian dollars).

Location	Consumer Surplus per Swimming Occasion	Source of Estimate
Ontario beaches	$4-8 [1]	MOE: Beach Use and Environmental Quality in Ontario (Reference #1-42
Six lakes in central Ontario	$6	MOE: Recreation Benefits Arising from Lake Reclamation in Ontario (Reference #I-45)

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1 Range reflects average round-trip travel times of one-half hour and one hour respectively.

EXHIBIT F-2: Estimates Of Consumer Surplus Per Day Of Recreational Fishing. (in 1989 Canadian Dollars).

Activity Being Valued	Location	Consumer Surplus per Angler-Day	Source of Estimate
Recreational Fishing	6 Ontario lakes	$12	DPA Study
Salmon Fishing	Victoria, B.C.	26	DPA Study
	Campbell River, B.C.	44	
	Sechelt, B.C.	51	
	Port Albemi, B.C.	90	
	Campbell River Guided	104	
Recreational Fishing	Alberta	34	Adamowicz and Phillips
Recreational Fishing	Haliburton/Muskoka Region, Ontario	25	Victor and Burrell
Angling	Lake of the Woods, Ontario	6	Hough, Stansbury and Michalski
Recreational Fishing	U.S.A.	Low:$23 Medium:46 High:70	Vaughan and Russell (1980)[1]
Trout Fishing	Fee-fishing sites, U.S.A.	36	Vaughan and Russell
Catfish Fishing/Rough Fish	Fee-fishing sites, U.S.A.	23	(1982)
Fishing	Adirondacks, N.Y.	47	DPA Study
Fishing	Snake River, Idaho	27	DPA Study
Water-based recreation[2]	Bow River, Alberta	Residents - $6 Non-residents - $22	Study for Alberta Government
Recreational Fishing	Great Lakes	46	Kealy and Bishop

1 Referenced in Victor and Burrell, "An Economic Assessment of Acid Rain Impacts on Sport Fishing in the Haliburton/Muskoka Region", (1983), Footnote 6.

2 Includes sportfishing equal to 78% of total user-days, boating equal to 20%, and other activities equal to 2%.

Appendix G

Basis For Calculation Of Non-Use Values

Section 5.4 estimates the non-use, or intrinsic, values associated with achieving the four water quality objectives at the RAP sites. Calculation of non-use benefits was based on:

- estimates of total "willingness-to-pay" (WTP) for achieving water quality improvements, including both use and non-use components, and

- an estimate of the portion which non-use value comprises of total WTP.

Estimates of total WTP were based on a review of a number of studies concerned with valuing water quality changes. Most of the WTP estimates in these studies were derived using the contingent valuation method (CVM).

As discussed in Section 5.4, the CVM is a relatively new technique and is still being developed. The discussion which follows:

- elaborates on some of the potential biases and limitations of the CVM;

- discusses some of the problems inherent in trying to compare different estimates of WTP;

- describes the studies which were reviewed to derive the estimates of WTP used in Section 5.4;

- discusses the basis for calculating the WTP and non-use value associated with each of the four water quality objectives; and

- discusses the method used to derive that portion of total WTP which reflects non-use (as opposed to use) benefits.

The Contingent Valuation Method—Potential Biases And Limitations

The contingent valuation technique uses sample surveys of people in a given area to determine their WTP for certain hypothetical environmental changes. For example, respondents may be asked how much they would be willing to pay to achieve improvements in air or water quality, or to prevent deterioration from current levels. Several types of potential biases have been identified in CVM studies. These include:

- **Hypothetical bias** —the respondents may not behave as they would in a real market situation.

- **Strategic bias** —the respondents may try to influence the results for personal reasons.

- **Information** bias—the respondent may not have sufficient information regarding the current and/or proposed hypothetical environmental conditions on which to assess his/her WTP for given measures.

- **Instrument bias - CVM** studies ask respondents for their **WTP** estimates using a variety of **question techniques.** Some use a "bidding" technique, starting at a given level of payment. Others ask an open-ended question, while others use a "payment card" which includes an array of numbers from which the respondent chooses one. Another type of instrument bias concerns the proposed "payment vehicle"—that is, the manner in which the payment, for improved environmental conditions, would be made. For example the payment vehicle might be an increase in sales taxes or an increase in water service fees (in the case of water quality improvements.) Use of different question formats and payment vehicles can result in substantially different estimates of WTP.

- **Sampling, interviewer, or non-respondent bias—**interviewers may convey their own biases in the way they ask the questions. As well, the type of sample chosen for the survey and the interpretation of non-responses poses problems when the sample results are expanded to the represent population as a whole. A number of approaches have been used to deal with these aggregation problems; however, to date there is no consensus as to the appropriate technique.

Other concerns regarding CVM studies include the potential inappropriateness of transferring results; the lack of clarity regarding the timeframe which is implied for payment for improved environmental conditions; confusion, on the part of both respondents and practitioners, regarding the relationship between use and non-use values in estimates of total WTP; and limitations imposed by the way in which different water quality standards are described in different CVM studies. These issues are discussed more fully in Section 5.4.

Difficulties In Comparing Estimates Of WTP

There are a number of differences in the approaches taken to estimate WTP which make it difficult to compare the results of different studies. These different approaches are described below. The discussion which follows uses as examples some of the studies listed in Exhibit G-1. (Reference numbers following the studies described refer to the bibliography contained in Appendix L).

A major difference in CVM study approaches concerns the distinction between estimates of use and non-use elements of economic value. Some studies estimate an overall WTP for improving (or protecting) the environment, and do not attempt to separate use and non-use components. The report in Exhibit G-1, done for the Ontario Ministry of the Environment in 1981 (Reference #I-43) falls into this category. Other studies attempt to disaggregate overall estimates of WTP. Studies in this category include two by Carson and Mitchell in 1981 and 1984 (Reference #1-12). A number of studies attempt not only to distinguish between use and non-use values, but also estimate values for various components of intrinsic benefits including option, existence, and bequest values [1]. This was the approach taken by Greenley, Walsh and Young (Reference #1-21)- and in a number of studies co-authored by Walsh and by Smith and Desvousges.

Further difficulties arise in terms of the definitions which are used to describe changes in water quality. Greenley *et al.* (Reference #I-21) describe three levels of water quality according to the quantity of heavy metals per litre of water. Smith and Desvousges (Reference #I-57) use a "water quality ladder' which describes the various qualities of water in terms of the activities which are possible at each level. The M.O.E. study (Reference #I-43) describes water quality in terms of the fish, wildlife, and plant habitat which the water could support. Given these differences in definition, judgement must be used in comparing the changes in water quality which are being valued.

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1 For an explanation of these terms, see Appendix E.

Differences also exist with respect to the magnitude and direction of change being valued. The focus of the M.O.E. study (Reference #I-43) is on prevention of environmental deterioration. Other studies value improvements in water quality. In some cases, the degree of change appears to be similar. However, it is not clear that individuals would be willing to pay the same amount for preventing a decline in water quality as they would for improving it by a comparable amount, or for equal but successive improvements.

Further differences exist with respect to the size, location and number of the resources under study. Presumably, the larger the body of water, or the greater the number of sites, the more individuals would be willing to pay to clean it up to a given level. Also, the "uniqueness" of the site or sites in question will influence WTP for protecting or improving water quality. Finally, the socioeconomic characteristics of the survey population will affect the resulting WTP's.

Notwithstanding these differences, it is possible to compare estimates of WTP in a general way. The following paragraphs describe each of the studies reviewed for this project, listed in Exhibit G-1. The final section of this Appendix uses the estimates of WTP from these studies to derive the estimates of WTP and non-use value used in Section 5.4.

Description Of Studies In Exhibit G-1

E. Clarke
DuPage River (Chicago)

This study, conducted in the late 1970's, attempted to measure the benefits of improving the DuPage River to meet the 1983 U.S. standards for swimmable and fishable waters. The study was based on a survey of recreationists at river sites and residents of the area. Estimates of WTP were then isolated for residents—including recreationists and non-recreationists - and for the nonresidents included in the recreationist survey. The results shown in Exhibit G-1 reflect the estimates for DuPage residents, including both recreationists and those surveyed at their homes (who may or may not be recreationists). As shown in Exhibit G-1, the results range from a low of $9 per household per year (in 1989 Canadian dollars) to a high of $132 per household per year. (These results were reported in an article by G.C. Blomquist—Reference #I-7. The Clarke study is, therefore, not referenced in Appendix I).

G. Gramlich
Charles River (Boston)

This study surveyed 165 Boston households in 1973 in order to determine WTP for improving the Charles River from "limited wildlife and some unpleasant odour" to water that is "fishable and swimmable." The study also estimated WTP by Boston residents for improving all rivers in the U.S. except the Charles River, and for improving all the nation's rivers, including the Charles River. The results, in terms of WTP for each of the three scenarios, were $99, $79, and $174 per household per year respectively (in 1989 Canadian dollars). The result shown in Exhibit G-1 reflects the WTP by Boston residents for cleaning up the Charles River only. (This study was described in an article by G.C. Blomquist — Reference #I-7 and is therefore not referenced directly in Appendix I.)

Binkley & Hanemann
Boston Beaches
(Reference #1-5)

This extensive study was based on a survey done in December, 1974 of Boston households in order to determine the factors affecting decisions to visit beaches within a one day trip of the Boston area. As part of the survey, respondents were asked how much they would be willing to pay to avoid deterioration, or to improve quality, at Boston area beaches. The resulting estimates ranged from $74 to $120 per household per year (in 1989 Canadian dollars) using the median and mean estimates, respectively. The authors support the former estimate—of $74 per household per year.

Carson & Mitchell
National Water Quality Improvements
(Reference #I-12)

Carson & Mitchell undertook studies in 1981 and in 1984 to estimate WTP for nation-wide water quality changes in the United States. Current national water quality was described as being mostly boatable. The hypothetical changes valued, which are reported in Exhibit G-1, were for retaining boatable water, improving the water to fishable levels; and improving the water to swimmable levels. In their 1981 study, nonuser WTP's were found to be roughly 47% of user WTP's. (It should be noted that the latter include some intrinsic value to users, and are therefore not only use value.) In their 1984 study, the authors estimate the lower bound of intrinsic benefits by dividing the non-users' WTP by the WTP for the total sample. Using this method, non-use benefits amount to between 19% and 39% of total WTP, depending on how non-use is defined. In the case of the lower estimate, non-use is defined as "no direct or indirect activities by anyone in the household", while in the case of the higher estimate, non-use is defined as "no instream recreational use of fresh water by the respondent in the past twelve months." A middle estimate of-30%—is derived when non-use is defined as no instream recreational use of fresh water by anyone in the respondent's household in the past twelve months. (Carson & Mitchell, Reference #I-12, page 14).

Ontario Ministry Of The Environment
Cottage Country
(Reference #1-43)

A study by the Ministry of the Environment was undertaken in July, 1981 to estimate individuals' WTP to prevent a decline in environmental quality due to pollution in Ontario cottage country—that is, the Muskoka/Haliburton Region, the Kawarthas, and Sturgeon Bay. Estimates were made on the basis of a survey of urban residents in Kitchener/Waterloo; cottagers; village residents; occasional visitors; and U.S.A. visitors. Levels of water quality were described by reference to a water quality ladder which graded the water from 1 to 10 according to the type of fish, wildlife and plant habitat which the water could support. The authors focus on the results obtained from asking respondents how much they would be willing to pay to prevent a deterioration, described as considerable, from level 8 to level 4. The WTP estimates reflect an overall value including both use and non-use elements. The result, in 1989 dollars per household per year, was $187 for village residents. Estimates for urban residents, cottagers, occasional visitors and U.S.A. visitors were higher.

F. Cronin
Potomac River

The results of this study were based on a survey of Washington, D.C. residents in the fall of 1973. Respondents were asked how much they would be willing to pay for improving water quality in the Potomac River. The results reported in Exhibit G-1 reflect WTP for improving water quality from boatable to swimmable. The results for users, including current users and "conditional non-users" (those who might use the river if it were cleaned up), ranged from $219 to $302 per household per year (in 1989 Canadian dollars), depending on the question format. Results for non-users ranged from $65 to $158 per household per year. (These results are as reported in Fisher & Raucher Reference #I-18, Table 4. The Cronin study is therefore not referenced in Appendix I).

Greenley, Walsh And Young
South Platte River Basin
(Reference #I-21)

The study by Greenley, Walsh and Young estimates the benefits associated with improving water quality in the South Platte River Basin in Colorado. Estimates were derived through a contingent valuation survey and employed two different types of payment vehicles—an increase in annual water service fees and an increase in the sales tax. The lower estimates in Exhibit G-1 reflect WTP when the proposed payment vehicle is an increase in water service fees and are about one-third as great as WTP based on an increase in sales taxes (shown as the higher estimates in Exhibit G-1).

Three levels of water quality are described in the study. "Situation C" ("severe pollution") is described as water quality where the content of heavy metals—at 181,250 micrograms per litre—exceeds biological limits for fish survival. "Situation B" ("moderate pollution") refers to water which is still toxic with a metallic content of 1,158 micrograms per litre. The water described by "Situation A" is pure and nontoxic. The authors estimate use values for a change from Situation C to Situation A, and for a change from Situation C to Situation B. Estimates of option, existence and bequest values are provided only for the change from C to A. However, estimates of non-use values for moving from severe to moderate pollution (C to B) were made based on the proportion which option, existence and bequest values for moving from C to A comprised of the total WTP for moving from C to A. The resulting estimates of total WTP for both changes in water quality are shown in Exhibit G-1.

J. Loomis
Mono Lake (California)
(Reference #I-30)

This study is based on a mail survey of a sample of California households during the spring of 1985 in order to determine the WTP of California households for preserving the ecology and scenic resources of Mono Lake. The study then used five different approaches for expanding the sample estimates, with considerable variation in the results. The estimate which the author supports is $44 per household per year (in 1989 Canadian dollars), as shown in Exhibit G - 1.

Smith And Desvousges
Monongahela River (Pennsylvania)
(Reference #I-57)

The study by Smith and Desvousges estimates use and option values for water quality changes in the Monongahela River (Pennsylvania) described according to five different levels on a water quality ladder. The lowest level (E) is extremely polluted; level D is suitable for boating but not fishing or swimming; level C denotes water quality such that gamefish like bass can survive; level B is swimmable; and level A is drinkable.

The survey form included four different ways of asking respondents how much they would pay for each given change in water quality, including:

- iterative bidding using $25 as a starting point;
- iterative bidding using $125 as a starting point;
- a direct question (open-ended);
- a "payment card" approach whereby the respondent selected his WTP value from an array of potential values.

The study reports estimates for all four question formats and for various changes in water quality. Because the changes from level D to level C and from D to B—that is, from boatable to fishable and swimmable respectively—are most relevant to the RAP sites, these are the results reported in Exhibit G-1. In both cases, the lower estimate reflects WTP derived by asking respondents a direct (open-ended) question; the higher estimates of WTP are those associated with the iterative bidding approach using $125 as a starting point. The remaining two question formats resulted in estimates of WTP falling between these upper and lower bounds.

Alberta Government
Bow River
(Reference #1-2)

As part of this study, conducted in 1986-87, a survey of households in the Bow River Valley area was conducted in order to determine their WTP for protecting the scenic and recreational features of the Bow River. Almost all non-user households were in favour of protecting the Valley; however, only 41% of Calgary households were prepared to pay an annual fee for this protection. For these households, the average amount they would be willing to pay was approximately $27 per year (converted to 1989 dollars). Thus, the average WTP across all households can be calculated as roughly $11 per year.

Estimate Of WTP Used In Section 5.4

Exhibit G-1 presents estimates of WTP for a variety of hypothetical water quality changes. As noted earlier, no attempt has been made to adjust these results for methodological, definitional, or conceptual inconsistencies, nor is it likely that such adjustments could be made with any degree of reliability. However, the results, as they stand, provide an indication of the range which exists in estimates of total WTP for water quality changes in general, and provide a basis for deriving a representative estimate of WTP for improving water quality at the RAP sites.

The Carson and Mitchell estimates shown in Exhibit G-1 reflect WTP for cleaning up all rivers and/or lakes in the U.S. Use of these results may overestimate WTP for improving water quality at one or a limited number of sites, such as the 17 RAP sites. The studies by Loomis and the Alberta Government reflect WTP for preserving, rather than improving, water quality. The latter results may underestimate the willingness to pay appropriate for application in this study, where the proposed remedial measures will result in an improvement, as opposed to a preservation, of water quality.

If these two sets of results are disregarded for the moment, the WTP estimates which are left provide a reasonable approximation of the WTP range which might be associated with improving water quality at one, or a limited number, of nearby sites. In all cases, the estimates generated by these studies reflect the WTP by residents at or near the site(s) in question. These estimates range from a low of $9 per household per year (the "low" estimate of WTP generated in the study by Clarke) to a high of $310 per household per year. The latter is the WTP estimate associated with improving water which is severely polluted to a pure state; this estimate may therefore over-state WTP for less dramatic water quality improvements such as are likely to take place at the RAP sites. Taking the simple arithmetic average of the remaining estimates suggests that WTP by residents for improving water quality at a nearby site (or, in the case of the 1981 Ontario MOE study—Reference #1-43 — for preventing considerable deterioration) is in the order of $130 per household per year (in 1989 dollars).

The estimates of WTP used to derive the figure of $130 represent WTP for varying degrees of water quality changes, described in a number of different ways. It is difficult to standardize these estimates so as to derive a consolidated estimate for each of the four water quality objectives used in this study. For the purposes of the calculation in Section 5.4, it is assumed that $130 represents the amount each household would be willing to pay annually to achieve swimmable water at the RAP sites. This represents WTP by both user and nonuser households. Thus, the figure of $130 includes both use and non-use components of economic benefit. Derivation of the non-use portion of total WTP is discussed below.

Derivation Of Non-Use Value Estimates Used In Section 5.4

Calculation of the portion of total WTP (of $130 per household per year) which reflects non-use value was based largely on the results of a study by A. Fisher and R. Raucher (Reference #I-18). This study reviewed a number of studies which estimated the intrinsic benefits of improved water quality, and attempted to isolate in each case that portion of the estimates which reflects nonuse benefits. The conclusion of the study was that non-use values are "...positive and non-trivial" and that these benefits ".. generally are at least half as great as recreational use benefits”.[1] This conclusion suggests that intrinsic value comprises roughly at least one-third of total WTP.

The above estimate is generally consistent with estimates by Carson and Mitchell who, in reporting the results of their 1984 study (Reference #I-12), estimate that intrinsic benefits range from 19% to 39% of total WTP, depending on how "non-use" is defined.[2] (For a description of these defmitions, see the Carson and Mitchell study description earlier in this Appendix.)

However, the Smith and Desvousges results suggest that, depending on the question format used in the survey, WTP by non-users (which is probably representative of non-use value) ranges from 35% to 80% of users' WTP. The latter includes both use and non-use benefits. If the non-use component of users' WTP could be removed from the estimates of user WTP, the resulting percentage which non-use value comprises of total WTP would be higher than the 35% to 80% noted above.

Thus, as an upper limit, it was assumed for the calculation of non-use benefits in Section 5.4 that non-use benefits would comprise approximately one-half of total WTP. It was assumed above that total WTP to achieve swimmable water at the RAP sites would be in the order of $130 per household per year. Thus, the non-use value derived from achieving swimmable water at the RAP sites is assumed to be in the order of $65 per household per year (in 1989 dollars).

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1 Reference #I-18, p. 60.

2 Reference #I-12, p. 14.

The studies listed in Exhibit G-1 suggest that total WTP for achieving "fishable" water is in the order of 50% to 85% of the WTP for achieving swimmable water. This suggests that non-use benefits for achieving fishable water will range from approximately $40 to $55 per household per year. The estimates in Section 5.4 are based on the assumption that achieving fishable water will result in intrinsic benefits equal to $50 per household per year. Although it is likely that there would be a higher WTP associated with achieving a quality of water which permits a "self-sustaining sportfishery" as opposed to a merely "edible sportfishery" (as implied by the water quality objectives used in this study), there is no basis upon which to make this distinction. Thus, for the purposes of this analysis in Section 5.4 it has been assumed that the non-use value associated with both sportfishery objectives is $50 per household per year.

No research has been done on WTP for aesthetic improvements per se. However, two of the studies listed in Exhibit G-1—those by Loomis and the Alberta Government—estimate WTP for preserving, as opposed to improving, scenic and ecological features. These estimates may be reasonable approximations of the lower bound for total WTP for aesthetic improvements at the RAP sites. Data from these studies suggest total WTP of approximately $11 per household per year in the case of the study done by the Alberta Government, and an average of $44 in the case of the Loomis study. On the basis of these estimates, it has been assumed that $30 represents a reasonable estimate of the amount each household would be willing to pay for aesthetic improvements at the RAP sites. It has been assumed that approximately one-half of this—or $15 per household per year—represents the non-use benefits associated with this water quality goal.

EXHIBIT G-1: Estimates Of Total Willingness-to-pay For Water Quality Improvements.
(1989 Canadian dollars per household per year)

Author	Location of Water Body	Water Quality Change Being Valued	Willingness-to-Pay	
E. Clarke (1977)[1]	DuPage River (Chicago)	To fishable & swimmable	Low:$9 Middle:57 High:132	
G. Gramlich (1977)[1]	Charles River (Boston)	To fishable & swimmable	$99	
Binkley & Hanemann (1978)	Beaches within one day of Boston	From "fair" to "good"	$74-120	
			(1981),	(1984)
Carson & Mitchell (1981 and 1984)	All rivers and lakes in U.S.	Retain boatable	$273	$147
		To fishable	347	257
		To swimmable	410	378
Ontario Ministry of the Environment (1981)	Cottage country	To prevent "considerable" deterioration	Village residents, $187[2]	
F. Cronin (1982)[3]	Potomac River	From boatable to swimmable	Users: $219-302 Non-users:65-158	
Greenley, Walsh & Young (1982)[4]	South Platte River Basin (Colo.)	From severe, to moderate pollution From severe pollution to pure	$71-216 $98-310	
J. Loomis (1985)	Mono Lake (Cal.)	To preserve ecology and scenic resources	$44[5]	
Smith & Desvousges (1986)	Monongahela River (Penn.)	From: a) boatable to fishable b) boatable to swimmable	$28 -67 $45-109	
Alberta Government (1987)	Bow River	To protect scenic and recreational features	$11	

1 As reported in G.C. Blomquist, "Measurement of the Benefit of Water Quality Improvements," (1983) (Reference #1-7).

2 After discarding "extreme" responses.

3 Results are as reported in Ann Fisher & Robert Raucher, "Intrinsic Benefits of Improved Water Quality. Conceptual and Empirical Perspectives" (1984), (Reference #1-18) Table 4. "Users" are defined as including current users plus those who would "use" the water if it were cleaned up.

4 Lower estimates represent results when proposed payment vehicle is an increase in water service fees. Higher estimates are based on a increase in sales taxes.

5 Represents average WTP for all California households.

APPENDIX H

BIBLIOGRAPHY FOR COST METHODOLOGY
AND
LIST OF CONTACTS

BIBLIOGRAPHY FOR COST METHODOLOGY

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Industrial Wastewater

U.S. Environmental Protection Agency

Jenny Helms	(202) 382-7155

- Office of Water, Industrial Technology Division
- pulp and paper and dioxin update

Urban Nonpoint Source Pollution Contacts

U.S. Environmental Protection Agency

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- Office of Water Regulations and Standards, Nonpoint Sources Branch

Metropolitan Washington Council of Governments

Thomas Schuler (202) 223-6800

- author guidebook on urban stormwater treatment

Maryland Department of the Environment, Sediment and Stormwater Administration

Greg Lindsey (301) 631-3553

- author studies and guidebooks on stormwater utilities

Michigan Department of Natural Resources

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- Rouge River RAP coordinator

Agricultural Nonpoint Source Contacts

Ontario Ministry of Environment

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- NPS studies, Ontario Rural Beaches study

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- International Joint Commission NPS work

Ontario Ministry of Agriculture and Food

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- Water Management Coordinator, Soil and Water Management Branch

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- "Tillage 2000" demonstration sites

Agriculture Canada

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- coordinates NPS and SWEEP programs

Greg Wall (519) 824-4120 ext. 2103

- scientist working on pilot demonstration watershed program (3 paired watersheds in Lake Erie area)

U.S. Environmental Protection Agency

Richard Kashmanian (202) 382-5363

- Office of Policy, Planning, and Evaluation, Office of Standards and Regulations, NPS programs

Steven Dressing (202) 382-7110

- Office of Water Regulations and Standards, Criteria and Standards Division, Nonpoint Sources Branch

Ken Adler (202) 382-2756

- Office of Policy Analysis, Water Economics Branch

Tom Davenport (202) 886-0209

- Great Lakes National Program office, NPS program

North Carolina State University (Agricultural NPS support to U.S. EPA)

Michael Smolen (919) 737-3723

- tracks Rural Clean Water Program projects; building computer data base

International Joint Commission

Al Duda (313) 226-2170

- Great Lakes Program NPS work

U.S. Department of Agriculture, Economic Research Service

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- Soil and Water Branch
- analyses of Rural Clean Water Program projects

Toxic Sediment Dredging and Disposal

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Office of Dredging and Navigation, Washington, D.C.

David Mathis (202) 625-2218

Appendix 1

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27. Kneese, A.V., Measuring the Benefits of Clean Air and Water, Resources for the Future, 1984.

A text book describing the theory behind valuation of environmental benefits, with case studies in air pollution and in rural and regional air and water pollution.

Chapter 10 describes two studies which estimate benefits associated with improvements in water quality. The first study by - Vaughan and Russell - estimates the national water quality benefit which would arise from an increase in sportfishable water resulting from various U.S. pollution control regulations. Estimates the increase in fishing participation which will take place in three different types of sportfisheries - cold-water game fish, warm-water game fish/pan fish, and rough fish. Then estimates the total annual benefits from this increased participation. The second study—by Carson and Mitchell—is described elsewhere in this Appendix.

28. Kreutzwiser, R. "The Economic Significance of the Long Point Marsh, Lake Erie, as a Recreational Resource," J. Great Lakes Resources 7(2), pp. 105-110, 1981.

Assesses the economic significance of use of public marsh at Long Point and Point Pelee on the north shore of Lake Erie. Estimates consumer surplus from fishing, hunting, nature viewing and other activities and estimates local spending generated directly and indirectly by these activities.

29. Loomis, J., and Walsh, R.G., "Assessing Wildlife and Environmental Values in Cost-Benefit Analysis: State of the Art," J. of Environmental Management 22, pp. 125-131, 1986.

Describes contingent valuation method for estimating wildlife and environmental values in cost-benefit analysis. Presents empirical estimates from a number of studies of the option, existence and bequest values of wildlife species and environmental resources, including water quality.

30. Loomis, J.B., "Expanding Contingent Value Sample Estimates to Aggregate Benefit Estimates: Current Practices and Proposed Solutions," Land Economics Volume 63, Number 4, November 1987.

Discusses five methods of adjusting contingent valuation sample responses to represent the whole population. Uses a study of willingness-to-pay for protecting Mono Lake in California to compare the different methods of aggregating WTP estimates.

31. Macerollo, C., and Ingram, M., "The Value of Water in The Grand River Basin: An Estimate of the Demand for Water in Ontario," Cdn, Water Resources J., Vol. 6, No. 1, 1981.

Estimates the demand curve for water and the price elasticity of demand, with reference to the Grand River Basin in Ontario.

32. Mendelsohn, Robert and G.M. Brown, Junior, "Revealed Preference Approaches to Valuing Outdoor Recreation," Natural Resources Journal Vol. 23, July, 1983.

Paper reviews a number of revealed preference approaches to value outdoor recreation, including the simple travel-cost method to the more complex hedonic travel cost and demand system model. The travel cost method evaluates only the demand for inputs into the recreation experience. The simple travel cost approach ignores the substitute sites and the value of the characteristics of sites. These issues are addressed by three more complex travel cost approaches described in the paper.

33. Martin, Larry R.G., "Economic Impact Analysis of a Sportfishery on Lake Ontario: An Appraisal of Method," in Transactions of the American Fisheries Society 116: 461-468, 1987.

Estimates the economic impact of sportfishing at or in the Bay of Quinte, based on data available from a survey of anglers conducted between May and November 1984, and between January and March 1985. Develops detailed estimates of expenditures by residents and non-resident anglers by item, and combines these with estimates of angler-days for residents and visitors available from the Ministry of Natural Resources to derive total angler expenditures. Applies a local multiplier of 0.209 to estimate total income generated.

34. McConnell, Kenneth E., "The Economics of Outdoor Recreation," in Handbook of Natural Resource and Energy Economics (A.V. Kneese and J.L. Sweeney, editors), Volume 2, 1985.

Describes the extent of and rationale for government involvement in the provision of outdoor recreation services; conceptual and empirical issues in estimating the demand or benefits of outdoor recreation; and issues relating to the quality of outdoor recreation.

35. Metropolitan Toronto and Region Conservation Authority, "Urban Fishing: Feasibility Study," 1986.

An evaluation of the potential for developing fishing in the Metropolitan Toronto area. A survey was used to generate information on potential use, need for improvement, and mechanisms by which an urban fishing program could function.

36. Mitchell, R.C. and Carson, R.T., "Option Value: Empirical Evidence from a Case Study of Recreation and Water Quality: Comment," Quarterly J. of Economics February 1985.

A criticism of the Greenley, Walsh and Young (1981) contingent valuation study of water quality in the South Platte River Basin, Colorado (see Reference #21).

37. Mitchell, Robert C. and Richard T. Carson, Using Surveys to Value Public Goods - The Contingent Valuation Method, Resources for the Future, Washington, D.C., 1989.

A text book devoted to the contingent valuation method. Contains an exhaustive bibliography of references relevant to valuation of environmental benefits, and a detailed list of contingent valuation studies.

38. Muller, A., "The Socioeconomic Value of Water in Canada," Inquiry on Federal Water Policy Research Paper #5, March 1985.

Attempts to estimate the value of water in the Canadian economy. Estimates average net willingness to pay for water for industrial uses, including paper products, chemicals, primary metals, petroleum, and food and beverage industries; for thermal cooling power; for agricultural uses; and for municipal uses. All of the latter constitute "withdrawal uses" of water. Also estimates the value of instream uses of water including hydro electricity, waste assimilation, commercial navigation and fishing, and recreational uses. Bases estimates for fishing on results from studies by Adamowicz and Phillips, and by Vaughan and Russell.

39. Ontario Ministry of Natural Resources (by Hough, Stansbury and Michalski Ltd.), "The Lake of the Woods Fishery: A Social and Economic Analysis," April 1982.

Analyzes the social and economic significance of the Ontario Lake of the Woods fishery. Results were developed for seven groups of anglers. Conducted interviews in 1980 to determine current use of the fishery and describes economic and social impacts of alternative lake management strategies.

40. Ontario Ministry of Natural Resources, "1985 Survey of Sportfishing in Canada - Highlights for the Province of Ontario," October 1986.

Provides data on number and characteristics of anglers; distribution of angler effort by region; distribution of angler effort by season; numbers of fish caught by species; species preference; fishing activity in Ontario in the last five years; trip characteristics of non-resident anglers and expenditures attributable in whole or in part to sportfishing in Ontario. Results are based on a survey of residents of Ontario who had fished and of non-residents who had purchased angling licenses in Ontario in 1985. (Full results of the Ontario survey are in draft form at MNR.)

41. Ontario Ministry of Natural Resources, "Lake Ontario Fisheries Unit 1988 Annual Report".

Describes work undertaken by MNR with respect to fisheries. Consists of a number of reports on varying subjects.

42. Ontario Ministry of the Environment (by A. Usher, J.B. Ellis and M. Michalski), "Beach Use and Environmental Quality in Ontario," May 1987.

Identifies and classifies beach sites in Ontario. Hypothesizes relationships between beach use and environmental, economic and social parameters. Estimates value to Ontario residents of beach swimming in Ontario. Uses the travel cost method to obtain estimates of the value of home based and non-home based beach swimming occasions.

43. Ontario Ministry of the Environment (by A.R.A. Consultants), "Acid Precipitation Effects - Value Awareness and Attitudes in Ontario—The Amenity Value Survey," July 1981.

Estimates individuals' willingness-to-pay to prevent a decline in environmental quality due to an increase in pollution in cottage country (Muskoka/Haliburton, the Kawarthas and Sturgeon Bay). Estimates were made on the basis of a survey of urban residents in Kitchener/Waterloo, cottagers, village residents, occasional visitors, and USA visitors. Changes in the environment are described with reference to a water quality ladder. Also assesses socioeconomic factors which might account for variation in willingness-to-pay values.

44. Ontario Ministry of the Environment (by Currie, Cooper and Lybrand Ltd.), "The Effects of Acid Precipitation on Recreation and Tourism in Ontario," June 1982.

Develops a framework for, and attempts to estimate, the economic implications of acid precipitation for tourism and recreation in Ontario. Estimates changes in direct expenditures due to changes in angler effort resulting from acid rain. Uses the travel cost method to estimate the annual value of lost fishing occasions as a result of acid rain in four different areas of Ontario.

45. Ontario Ministry of the Environment (by DPA Group Inc.), "Recreation Benefits Arising from Lake Reclamation in Ontario," May 1987.

Assesses the economic implications of reclamation projects in six Ontario lakes with reference to one reclamation activity - a 25% reduction in phosphorus concentration. Focuses on three water-based activities — sportfishing, swimming, and boating. Estimates the economic impact of phosphorus reduction. Also does an extensive analysis of changes in consumer surplus for fishing, swimming and boating as a result of the reclamation activity. Suggests linkages between water quality and consumer surplus for activities. Supports the notion of a horizontal supply curve at a price equal to the average price of a recreation day.

46. Ontario Ministry of the Environment (by J. Donnan), "Mercury Pollution in the Wabigoon-English River System," January 1986.

A socioeconomic assessment, including benefit-cost analysis, of remedial actions proposed for reducing mercury contamination in fish on the Wabigoon-English River System. Does not estimate quantitative benefits associated with sportfishing.

47. Ontario Ministry of the Environment, "Beach User Benefits Study — Statistical Analyses File Report," (by Ecologists Limited), March 1989 — Draft.

Describes the results of a survey of beach users at five southern Ontario beaches during the summer of 1988. Results reported include characteristics and origin of respondents, duration of beach visits, participation in beach activities, travel characteristics, importance of beach attributes, perceptions of water quality, and effects of water quality on travel time and number of visits to beaches. Also estimates willingness to pay for improved water quality using a contingent valuation approach, and the travel-cost method. In connection with the latter, the study estimates unavoidable and discretionary costs per trip associated with each visit.

48. Ontario Ministry of the Environment (by Marshall Macklin Monoghan Limited and Peat Marwick Consulting Group), "Assessment of Proposed Remedial Action Plans for Hamilton Harbour," April 1988.

A cost-benefit assessment of proposed remedial and mitigating measures for Hamilton Harbour. The analysis focuses on a self-sustaining edible warm water fishery as the preferred end use.

49. Ontario Ministry of Tourism and Recreation, "Economic Impact of Tourism in Ontario," 1985.

Calculates the direct and indirect/induced effects of tourism expenditure in Ontario in 1985 and expresses these in terms of gross output, total income, wage and salary income, employment and taxes by region and sector of original expenditure. Estimates income and output multipliers for 26 industries for Ontario. Estimates income and output multipliers for tourism for the 12 Travel Association Regions in Ontario. (Report updates a similar study done by MTR for 198I.) A related report—"Economic Impact of Tourism in Northern Ontario" — discusses reasons for the decline of the economic impact of tourism on northern Ontario relative to the rest of the province.

50. Organization for Economic Co-operation and Development, "Environmental Policy Benefits: Monetary Valuation," (1989).

Describes techniques and procedures for estimating the monetary value associated with social advantages accruing from improvements in environmental conditions.

51. Pearse, P.H., Bertrand, F., and MacLaren, J.W., "Currents of Change: Final Report of the Inquiry or Federal Water Policy," Environment Canada, September 1985.

Assesses "the adequacy of federal water policy and the capacity of our institutions to respond to changing circumstances." Considers current water conditions and future requirements for water. Incorporates the results of several studies on special problems.

52. Randall, Allan, Berry Ives, and Clyde Eastman, "Bidding Games for Valuation of Aesthetic Environmental Improvements," J. of Environmental Economics and Management, 1,132-149, 1974.

Estimates the economic benefits associated with reducing aesthetic damages from a coal strip-mining and steam electric generation development in the Four Corners Region of the Southwestern U.S. Focuses on visibility effects.

53. Raphael, C.M. and E. Jaworsky, "Economic Value of Fish, Wildlife and Recreation in Michigan's Coastal Wetlands," Coastal Zone Management Journal, Vol., 5, #3, 1979.

The term "value" in this paper refers to a expenditures, rather than consumer surplus. Estimates annual expenditures by recreational participants and the gross annual return from Michigan's Coastal Wetlands.

54. Report to Pollution Probe/Lake Ontario Organizing Network on "American and Canadian Attitudes Towards the Environmental Problems in and Around Lake Ontario,". Prepared by Decima Research (Fall, 1989).

Describes the results of a survey of Ontario residents, conducted in August and September, 1989, to determine levels of concern and attitudes towards governments policies regarding environmental issues.

55. Schulze, William D., Ralph C. d'Arge, and David S. Brookshire, "Valuing Environmental Commodities: Some Recent Experiments," Land Economics, Volume 57, number 2, May 1981.

Describes the theoretical framework for valuing environmental amenities and biases contained in the contingent valuation approach. Describes six studies which attempted to value environmental goods (three visibility studies, one concerning environmental damages from geothermal development, a wild life experience valuation, and air quality). The six studies are then examined in terms of their approach and potential biases.

56. Sellor, C., John Stool and Jean-Paul Chavas, "Validation of Empirical Measures of Welfare Change, A Comparison of Non-Market Techniques," Land Economics Vol 61, #2, May 1985.

Good description of theoretical measures of welfare change, including "equivalent" and "compensating" measures (Hicks, 1943) and the Marshallian definition of consumer surplus. Describes the travel cost and contingent valuation methods, and advantages and disadvantages. Provides the results of three studies - (a) goose hunting experiment, (b) environmental impact of geo-thermal energy project, (c) clean air in L.A. Study also estimates the value of recreational boating in Texas. Compares results obtained using the travel cost versus the contingent valuation method.

57. Smith, K. and Desvousges, W., Measuring Water Ouality Benefits, Boston: Kluwer-Nijhoff Publishing, 1986.

A comprehensive discussion of different aspects of measuring benefits associated with changes in water quality. Describes the conceptual basis for estimating benefits including use versus non-use values; the concept of consumer surplus; different welfare measures, including compensating and equivalent variation and compensating and equivalent surplus. Describes different approaches for measuring benefits including the travel cost method, the contingent valuation approach, and the contingent ranking approach. Describes results of the authors' study of the benefits of improving water quality in the Monongahela River basin in Pennsylvania and West Virginia. Used the contingent valuation approach to estimate willingness to pay for various changes in water quality around five levels. Chapter 5 summarizes recent studies done to estimate option values.

58. Sutherland, Ronald J., "A Regional Approach to Estimating Recreation Benefits of Improved Water Quality," J. of Environmental Economics and Management, 9, 229-247, 1982.

Uses the travel cost method to estimate the recreation benefits from achieving "fishable and swimmable" water in the Pacific Northwest of the U.S. The study considers four water-based recreational activities (including fishing, camping, boating, and swimming) at 179 sites distributed over three states (Washington, Idaho and Oregon). Estimates the change in economic benefits which arises from improving water quality at all 179 sites to fishable and swimmable standards.

59. Toronto Star Marketing and Information Dept., "A Report on Recreational Salmon Fishing in Lake Ontario and the Toronto Star Great Salmon Hunt," June 1980.

Presents the results of a survey of people involved in the Great Salmon Hunt in 1979. Types of data gathered include a profile of participants, fishing occasions and time spent fishing, purchases of specified items, and estimates of per capita expenditures and total expenditures.

60. Tourism and Outdoor Recreation Planning Study Committee, "Ontario Recreation Survey," October 1977.

The Ontario Recreation Survey describes the results of a survey of Ontario residents conducted between May, 1973 and April, 1974. The survey results are described in seven volumes, and deal with such subjects as the "incidence, frequency, and location of recreational participation; and the travel mode, accommodation type, and destination of the weekend and vacation trips of Ontario residents." (ORS, Volume I, page 1).

61. Tuomi, A.L.W., "The Role and Place of Sportfishing in Water-Based Recreation," Cdn. Water Resource J., Vol. 7, No. 3., 1982.

Summarizes several measures of the economic dimensions of Canada's sportfisheries based on results of the 1980 survey of sportfishing. Recommends continuing development of sportfisheries statistical systems and data, and describes the type of systems and data required, so that the results of benefit-cost assessments can be used to mitigate and/or stop the damage caused by acid rain on fisheries.

62. U.S. Environmental Protection Agency (by the Research Triangle Institute), Benefit-Cost Assessment Handbook for Water Programs, Vol. 1, Washington, D.C., April 1983.

Describes procedures and steps for evaluating the economic aspects of proposed water policies. Discusses benefit-cost assessment, and how it differs from benefit-cost analysis, and outlines the steps to be taken in conducting a benefit-cost assessment. Discusses, among other things, treatment of the distribution of benefits and costs; discounting; types of benefits of water quality programs and methods of measuring these benefits. Presents case studies to illustrate the different methods of measuring benefits and shows how to complete a benefit-cost assessment.

63. Vaughan, W.J. and Russell, C.J., "Valuing a Fishing Day: An Application of a Systematic Varying Parameter Model," Land Economics, Vol. 58, No. 4, November 1982.

Estimates the value, in terms of average willingness-to-pay, of a day of fresh water recreational fishing differentiated by fish species sought. Results are based on a survey of fee-fishing sites in the US in 1979. The authors support the "household production function theory" whereby the consumer produces final service flows using consumption technology, time, purchased goods, and non-market goods inputs. Species considered in the analysis are trout and catfish. Presents estimates of consumer surplus when the cost of travel time is included and when it is excluded.

64. Victor and Burrell, "A Bio-Economic Evaluation of the Effects ofFossil-Fired Generating Stations on Water Quality," prepared for Ontario Hydro, August 1989 - Draft.

Estimates the loss of use benefits arising from a decline in fish yields in lakes in Ontario and parts of Quebec as a result of proposed exports of electricity to U.S. and the associated increase in emissions from fossil-fired generating stations. Does not estimate costs to non-users. Estimated the decline in fish yield as a result of acidification of lakes, and the resulting decrease in angler activity. The annual value

of these losses were calculated using an estimate of consumer surplus per angler-day of $24 (in 1988 dollars). This figure is derived from VHB's 1983 study (see below), but a number of other consumer surplus estimates are also presented.

65. Victor, P. and Burrell, T., "An Economic Assessment of Acid Rain Impacts on Sportfishing in the Haliburton/Muskoka Region," January 1983.

Uses the Talhelm approach to estimate the economic welfare losses due to responses of sportfishermen to acid deposition in the Muskoka/Haliburton region. The essence of the approach is to "estimate demand curves for sportfishing and then see how the consumer surplus from fishing changes if acid rain reduces the supply of fishing". Supports the notion that supply curves are perfectly elastic "on the assumption that anglers can return as often as they like, at the same price, to the nearest lake that provides any particular 'product'." Estimates consumer surplus losses to the year 2032 for a total of 232 lakes in the Muskoka/Haliburton region assuming increases in acid rain.